MANORAMA

TELL ME WHY

No:85

LIGHT

ALL ABOUT THE AMAZING WORLD OF OPTICS

MANORAMA
TELL ME WHY
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FROM THE HOUSE OF
MAGIC POT, THE WEEK,
MANORAMA YEARBOOK, VANITHA
& THE MALAYALA MANORAMA DAILY

Lead, Kindly Light

From the beginning of time, Man has been fascinated by the phenomenon of light. Our forefathers believed that our eyes sent out light so that we could see things. Yet, there were many enquiring minds that were not satisfied with this explanation. The questions raised by them triggered the study of light, and this eventually evolved into the science of Optics.

The trailblazers in the field of Optics identified light as a form of energy that travels at the incredible speed of 299,792, 458 metres per second in a vacuum! It is not just the speed of light that is amazing - every aspect of it captivates, entrances, and boggles the mind. As Diwali, the glorious festival of lights, approaches, get ready to be transported into the wondrous world of light, in this exciting issue of Tell Me Why.

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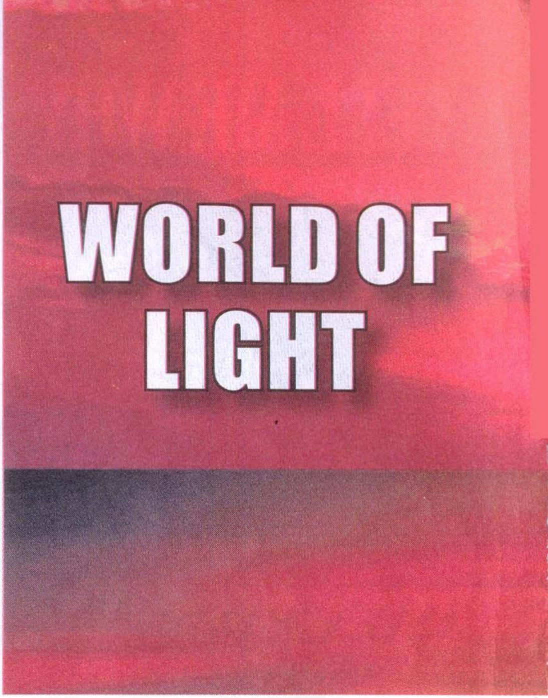


WORLD OF LIGHT

What is light?

We all know what light is. We also know that the Sun, fire, bulbs, and glowworms all give us light. But what exactly is light?

Light is a form of energy that which we can see. It is made up of billions of tiny particles called photons. These photons travel from one place to another in waves.

The light that we can see consists of photons that move at a wavelength that makes it visible, and is known as visible light.

Visible light is actually made up of different colours. Among the different photons that are in visible light, the ones that have the longest wavelength look red to us, and the ones that have the shortest wavelength look violet to us.

Red, green, and blue are the primary colours of light. Mixing them in various ways will make all other colours, including white. Isn't that amazing?

I think this is the time to recharge my torch...

Why was the Sun considered a God in ancient times?

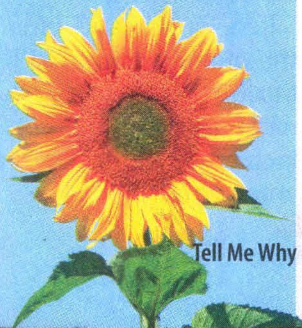
People through the ages have worshipped the Sun as the source of light, and therefore, as the source of all life. Our ancestors realized that if there was no Sun, the Earth would be plunged in perpetual darkness. It would be unbearably cold, and all the water on Earth would freeze up. They had no clear idea of how the Sun produced light, nor why it moved throughout the sky. They did understand however, that without the Sun, life would not be possible.

Ancient civilizations were primarily agricultural, and depended on the Sun for life, and their crops. Therefore, it is no surprise that they worshipped the Sun as a God.

CURIOUS FACT

The Sun and Flowers

Our ancestors observed that leaves and flowers of certain plants often turned to follow the movement of the Sun in the sky during the course of a day. This plant, known as 'sunflower' in English, was used in ancient times to worship the Sun by certain civilizations of Central and South America.



Why is light responsible for life on Earth?

Without light, there would be no life. Plants need light to produce food through the process known as photosynthesis. Light is the only way for plants to get the energy to grow. Animals depend on plants for their food, either directly, or indirectly. Human beingstooeat plants, oranimals that eat plants. Without light, all the plants on Earth would die - and animals and people would be left without food, and would die too.

Light is also important because it gives the Earth the warmth needed to support different forms of life.

Grow up, grow up baby....

Some living creatures like fireflies create their own light. Others, like Man, have learnt to create artificial light when natural light is not available.

Light lets us see things. Without any light, we would see nothing at all.

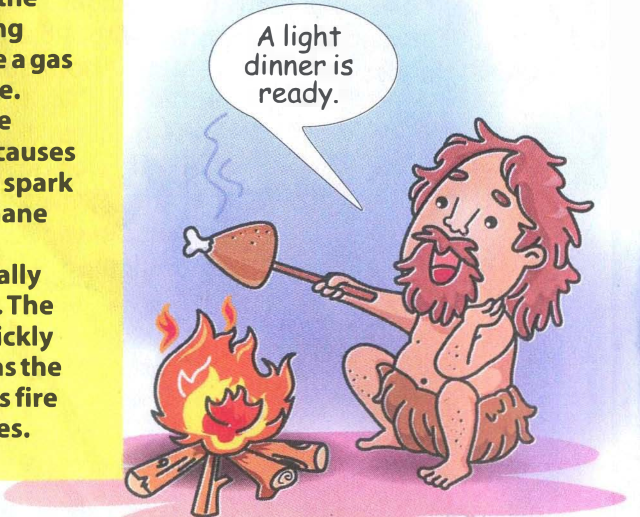
Magic Flames

Have you heard of the term 'will o'the wisp'? It refers to a flame that is often seeing moving by itself over marshy areas - quite an eerie phenomenon. There is a simple explanation for this however. The rotting plants in a marsh or swamp produce a gas called methane, while the remains of rotting animals produce a gas called phosphine. When phosphine meets the air, it causes a spark, and this spark ignites the methane that is present, creating a naturally occurring flame. The flame moves quickly over the marsh as the methane catches fire in different places.

How did Man make light?

One of the biggest achievements of Mankind was when our ancestors learnt how to make fire in the distant past.

Early Man depended on the Sun for light during the day, and on fire for light at night. Later, people learnt that by rubbing two stones or two pieces of wood together, they could produce a spark. This discovery proved to be a turning point in the history of mankind, for it provided early Man with the knowledge to start a fire that would provide him with light, warmth, and safety from wild animals.


A light dinner is ready.

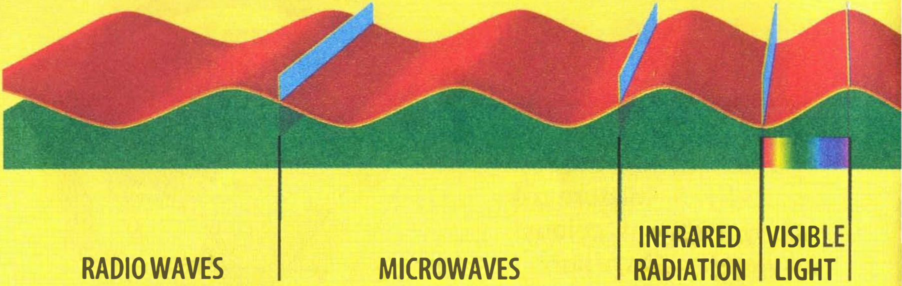
Why is sunlight white, while a rainbow has many colours?

Come on light, join with me. Let's make a rainbow.

The light from the Sun is really a mixture of many different colours or wavelengths of light.

The wavelength is simply the distance in which a wave repeats itself. Red light has a long wavelength, while violet light has a short wavelength. The light that we can see, or visible light, is actually made up of different wavelengths that we see as red, orange, yellow, green, blue, indigo, and violet light. These colours gradually merge into one another, and the mixture produces white light.

As white light passes through droplets of water in the sky, the light is refracted or bent. The longer wavelengths of light are refracted more than shorter wavelengths. This causes the colours to be separated as they pass through the raindrops. The result is the rainbow of seven colours that you see in the sky!



What are electromagnetic waves?

The heat produced by the Sun travels from the Sun to the Earth via waves known as electromagnetic waves. These waves can vary greatly in their wavelength.

Electromagnetic waves possess both electric and

What is the speed of light?

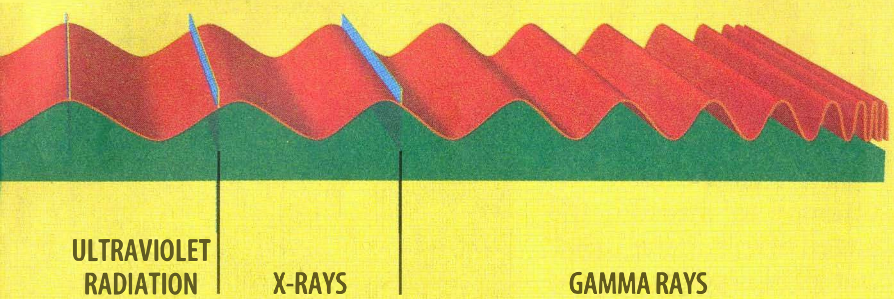
We know that light travels in waves. These waves are not of the same wavelength. Some wavelengths are longer than others. However, all waves move at exactly the same speed in a vacuum.

When we talk about the speed of light, we are referring to the speed at which light

STAR FACT

Light to Lead

In ancient times, people made fires at the edge of the water to warn boats of dangerous rocks and shores. Later, lighthouses were built to serve this purpose. The first proper lighthouses were built by the pharaohs of Alexandria.



Electromagnetic Spectrum

magnetic properties. Because the electromagnetic waves traveling to the Earth from the Sun come in a variety of lengths, scientists consider them to be a spectrum. Thus, we call all these waves together the 'electromagnetic spectrum'.

Electromagnetic waves are divided into many categories. The shortest waves are gamma rays, x-rays and ultraviolet waves. The medium sized waves are called visible light waves. Radio waves, micro waves and infrared waves are the longest waves.

travels. This is now defined as 299,792.458 km per second in empty space.

To get an idea of how fast this is, light can travel about seven times around the Earth in one second! Astronomers use the speed of light to measure how far away things are in space. They use a unit called the light year, which is the distance that light can travel in one year.

The problem is we're going faster than light. Can't see what's ahead.
SPEED

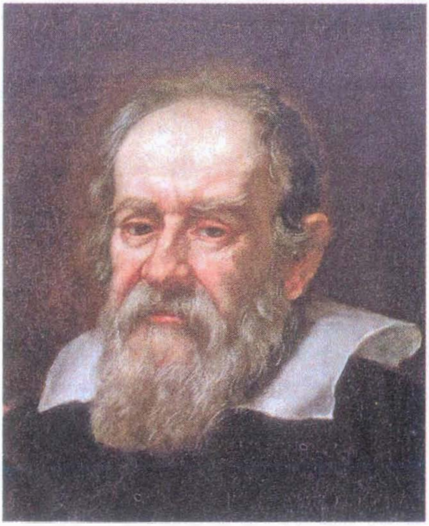
How did scientists arrive at a figure for the speed of light?

Galileo, the famous Italian scientist, made an attempt to measure the speed of light in the 1630s, but all he could prove was that light travelled very fast.

In 1728, an English astronomer, James Bradley, calculated the speed of light from the direction in which light fell from a star to Earth. He came up with a figure of 301,000 kilometres per second.

In 1849, another scientist, Fizeau, improved on Bradley's calculations, and came up with a new figure: 313,300 kilometres per second.

In 1923, Albert Michaelson changed the figure for the speed of light. He said it was nearly 299,798 kilometres per second. In 1970's, the speed of light was officially approved to be 299,792.458 kilometres per second.



Galileo

CURIOUS FACT

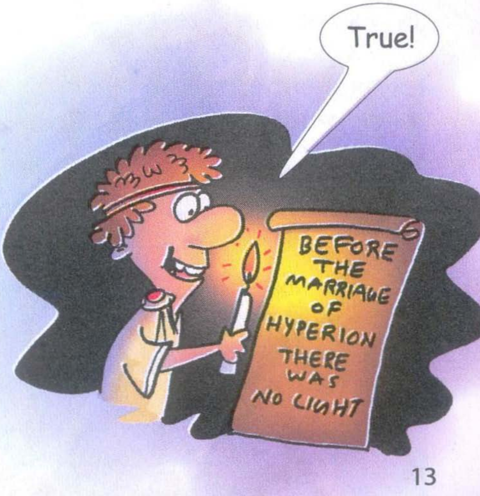
Moonlight

The biggest object that bounces sunlight is the Moon. Though we talk of moonlight, the Moon has no light of its own. It merely reflects light from the Sun.

Why is Hyperion associated with light?

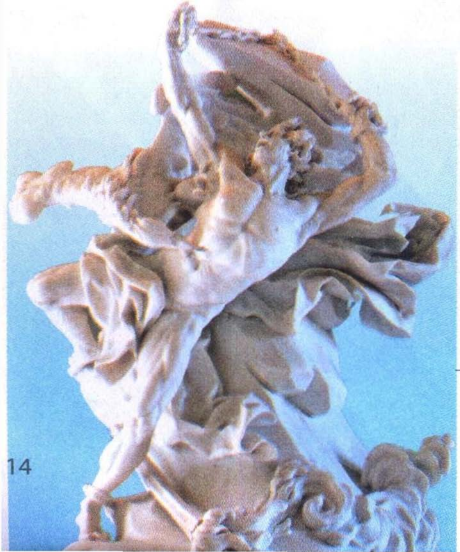
Hyperion was the Titan God of Light. The Titans are the parents of many of the Olympian gods and goddesses worshipped by the ancient Greeks.

Hyperion' means 'he who goes before the Sun.' He is sometimes called the 'Titan of Light'. Hyperion is the father of the sun, moon, and dawn. Hyperion married his sister, Theia, and they had three children. They were Helios or the Sun, Eos or Dawn, and Selene or the Moon. So, Hyperion's children were said to bring light to the world.


True!
BEFORE THE MARRIAGE OF HYPERION THERE WAS NO LIGHT

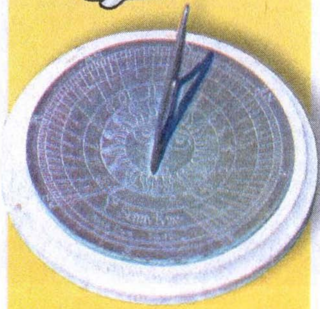
Why is Prometheus associated with light?

Prometheus was a Titan who is credited with bringing enlightenment to humans. He stole fire from the gods, and gave it to mankind, bringing the power of warmth and light to the dark and miserable Earth. By doing this, he angered the gods, who wanted to keep the power of fire and enlightenment for themselves. So Zeus, king of the Olympian gods, punished Prometheus by chaining him to a rock in the Caucasus Mountains. Every day, his liver was devoured by a giant eagle, only to regenerate overnight. Generations later, the great hero Heracles came along and released the old Titan from his torture.



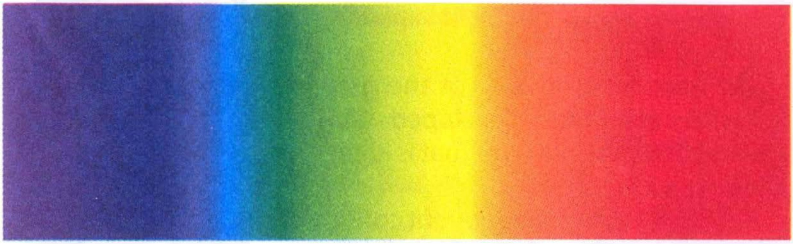
Sculpture of Prometheus

CURIOUS FACT



Sun Time

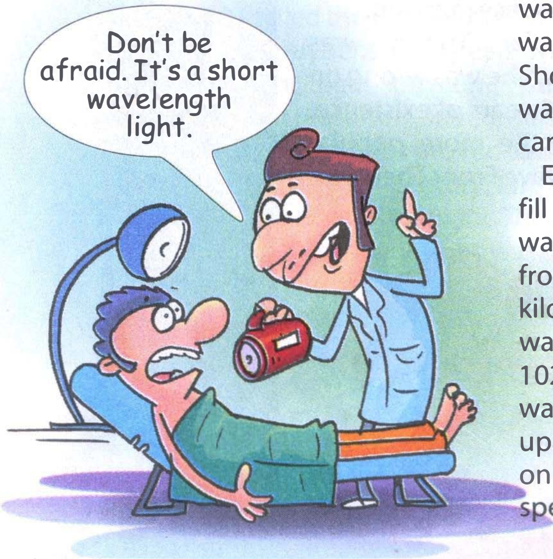
Sundials were used by many ancient cultures to help the people know what time it was. A stick was pushed vertically into the ground, and the time of the day could be calculated by seeing where its shadow fell.



Visible Spectrum

What is the importance of wavelength in electromagnetic radiation?

Electromagnetic radiation refers to a form of energy emitted and absorbed by charged particles, as it travels through space. This energy travels throughout the universe at the speed of light, in the form of waves.


Don't be afraid. It's a short wavelength light.

What separates one type of electromagnetic radiation from another is its wavelength.

Wavelength is important because it determines the characteristics of a wave. Longer wavelength waves such as radio waves carry low energy. Shorter wavelength waves such as x-rays, carry higher energy.

Electromagnetic waves fill a spectrum with wavelengths that vary from thousands of kilometres long, down to wavelengths more than 1020 times smaller. The wavelengths that make up visible light comprise only a tiny fraction of this spectrum.

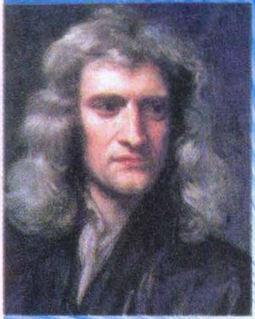
Why is Newton's Theory of Light important?

Sir Isaac Newton, one of the greatest scientists of all time, developed a fundamental theory about light that is known as the Corpuscular Theory.

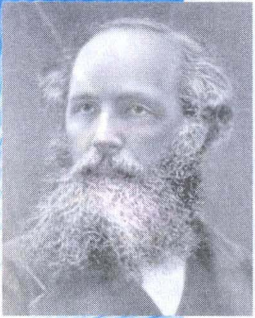
According to this theory, light consists of corpuscles which are a stream of discrete, tiny, light and elastic particles that travel in perfectly straight lines in all directions. Every luminous source like the Sun, or a lamp, or a candle, emits these corpuscles. According to this theory, we are able to see different colours because of the difference in sizes of these corpuscles.

The theory also stated that when corpuscles hit a surface, each particle is reflected, and that when light travels from air into water, it will increase in speed.

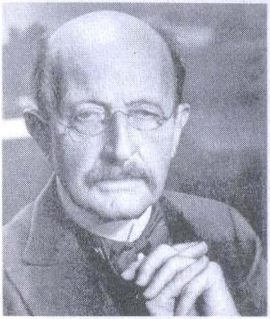
Newton's Corpuscular Theory was important, even though he was wrong on some points. After 100 years of existence, it later gave way to the more popular Christiaan Huygens' Wave Front Theory.



Sir Isaac Newton



James Maxwell



Max Planck

Christiaan Huygens

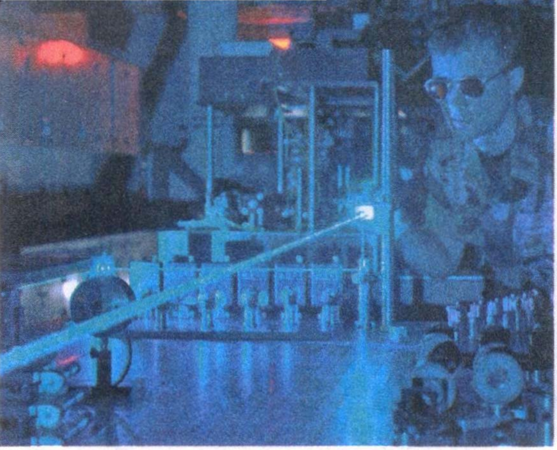
What are the other important theories of light?

In 1678, Dutch physicist Christiaan Huygens stated that light is made up of waves vibrating up and down, perpendicular to the direction in which the light is travelling. Huygens' Theory is called the Wave Front Theory.

Huygens disagreed with Newton, and said that light traveling from air to water will decrease in speed, and vice versa. Later, Huygens was proved to be correct.

In the 19th century, James Maxwell put forward the Electromagnetic Theory of Light. According to this theory, light waves are a part of a larger family of electromagnetic waves, and make up the electromagnetic spectrum.

The 20th century ushered in the Quantum Theory put forward by Max Planck, a German scientist. It stated that light waves travel as separate packets of energy called quanta or photons, and it is this theory that is widely accepted today.



Emission of Photons as a Laser Beam

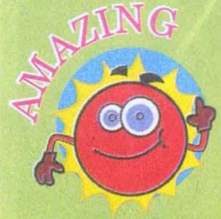
What are photons?

A photon is a bundle of electromagnetic energy. It is the basic unit that makes up all light. The photon is sometimes referred to as a 'quantum' of electromagnetic energy.

All light is made of photons that are so small that they cannot be seen individually. They behave in some ways like particles, and in other ways like waves.

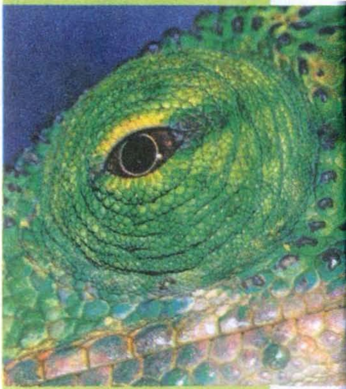
It is not just sunlight and visible light that is made up of photons; radio waves, television broadcasts, x-rays, and the ultraviolet rays are all made up of photons.

The original concept of the photon was developed by Albert Einstein, but it was scientist Gilbert N. Lewis who first used the word 'photon' to describe this bundle of electromagnetic energy.



Chameleon's Eyes

A chameleon's eyes have a 360-degree arc of vision. It can rotate each eye independently of the other, and so, can see two directions at once.



Why do shadows form?

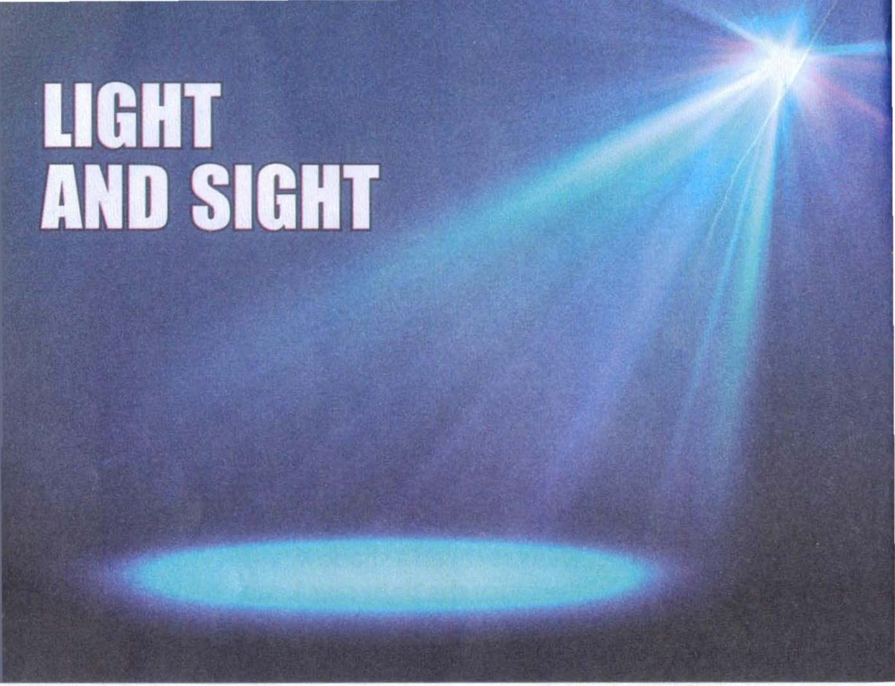
All of us have seen our shadows when we go out in the Sun. In fact, all objects including trees and houses have a shadow when they are in sunlight. Why does this happen? Sometimes ,objects are able to block light. An object through which no light can pass is called opaque. An example is our body. Since light cannot pass through, it creates a dark area around the object. This patch where no light falls, is called a shadow.

A shadow moves because the light rays keep changing their direction in which they fall on the object. If the object moves, then again the shadow moves, as it is formed whereever the object blocks light.

Shadows are longest in the early morning and late evening, and shortest at noon, because of the angle at which sunlight falls on an object.

Mr. Watson. I'm searching for the shadow of this light.

LIGHT AND SIGHT



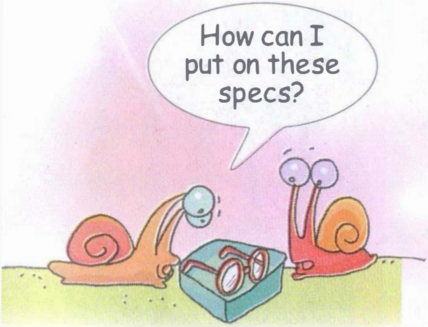
Why are we able to see things?

In order for us to see, light enters our eyes through the black spot called the pupil which is really a hole in the eye. The pupil can change sizes with the help of the coloured part around it, a muscle called the iris. By opening and closing the pupil, the iris can control the amount of light that enters the eye.

Once the light is in our eye, it passes through fluids, and lands on the retina at the back of the eye. In order for the light to be focused on the retina, our eyes have lenses.

The retina turns the light rays into signals that our brain can understand. The retina uses light-sensitive cells called rods and cones to see. The rods are extra sensitive to light, and help us to see when it's dark. The cones help us to see colour.

The retina changes light into electrical signals for our brain. The brain translates them into the images that we see.


How can I put on these specs?

Why are the eyes of some animals amazing?

Many animals have adaptations that make their eyes truly amazing.

Pigeons can bend their cornea - the transparent, dome-shaped window covering the front of the eye that bends light- and this allows them to bring objects into sharper focus.

The squid can move its lens away, or towards the retina, while diving birds have extra muscles around the lens that squeeze it to give sharper focus.

Butterflies have two sets of eyes, and their compound eyes are among the most complex in the world, for they allow butterflies to see one of the broadest ranges of colour available to any animal on the planet.

The snail has evolved a unique pair of eyes that settle at the tips of their eyestalks, located on the head. When sensing any danger, the snail is able to quickly retreat its eyes into a protective shell, keeping them free from injury!

In short, animals have an incredible variety of eyes. The list is extraordinary, and practically never-ending.

Why are the eyes of simple marine animals special?

The simplest forms of eyes are not eyes in the sense we know but light-sensitive areas called eyespots which can only detect differences between light and dark.

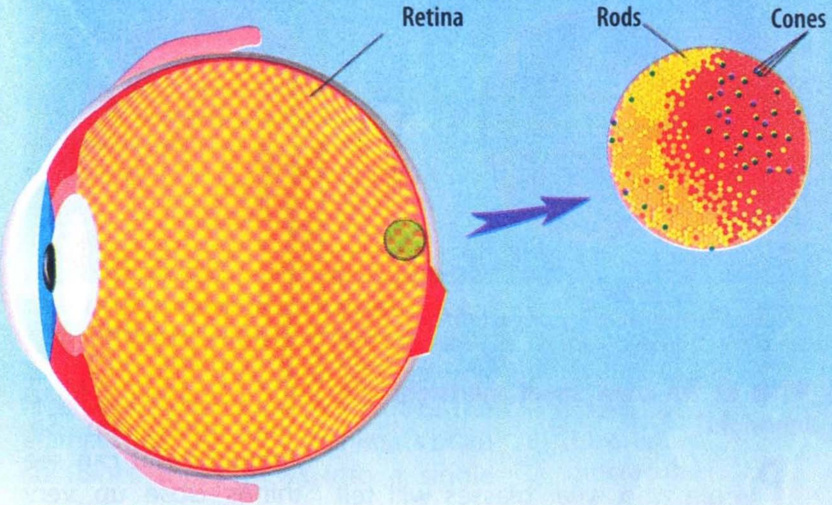
Eyespots are found in certain algae and single-celled marine organisms. Over the ages, some simple forms of marine life developed primitive eyes called ocelli, which can distinguish between light and shadow, though they are unable to form an image.

The microscopic marine organism called Copilia has remarkable eyes which make up more than half of its transparent body, and these eyes can actually form images.

CURIOUS FACT

Eyes over Water

The mudskipper, a small fish that spends much of its time on land hunting for food, has eyes that pop up like twin periscopes when it goes into the water. These eyes sit on stalks, and periscope above the surface, while the rest of the mudskipper remains safely underwater.



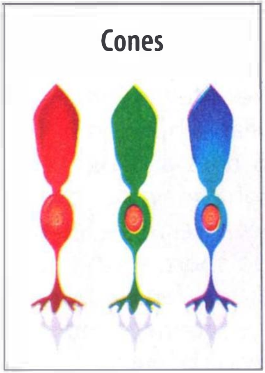
What are rods and cones?

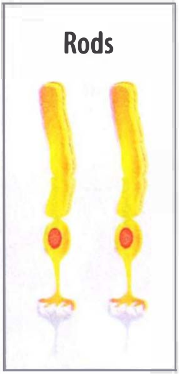
Rods and cones are special cells that line the retina of the eye. They get their names from their shapes.

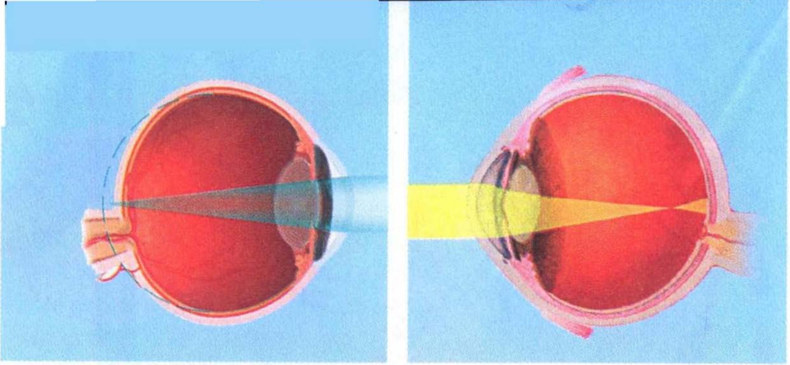
Rods are highly sensitive cells located in the outer area of the retina -the lining of the back of the eye. They are used in areas of dim light, and are sensitive to light, shape, and movement changes.

Cones are located in the central area of the retina. Cones play a key role in our ability to see colour.

When light falls on these cells, the chemicals in them are altered, and send signals to the brain that translates these signals into images.



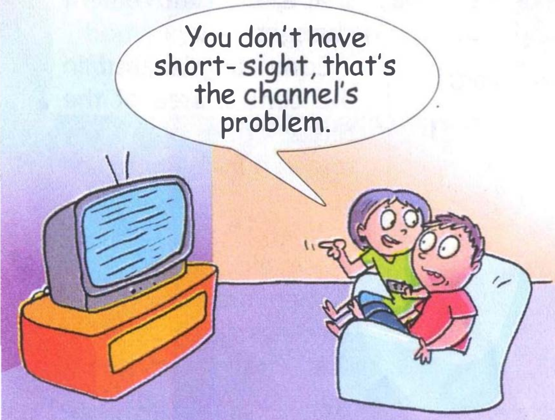




Long-sight and Short-sight

What do we know about shortsight and longsight?

People who wear glasses will tell you that they are short-sighted or long-sighted. Do you know what this means? You are short-sighted if your eye is too long from front to back, or if the curve of your cornea is too steep. This means that the length of your eye and its power to focus don't match up. So, although you can see things close up very clearly, things in the distance are blurred - like the blackboard in a classroom.


You don't have short-sight, that's the channel's problem.

Long-sight is when you can see things that are far away better than you can see things close up. For example, you might be able to watch the television very clearly, but find it hard to read a book. Long-sight may be caused because the eyeball is too short, so that light rays are focused behind the retina, and the image is blurry.

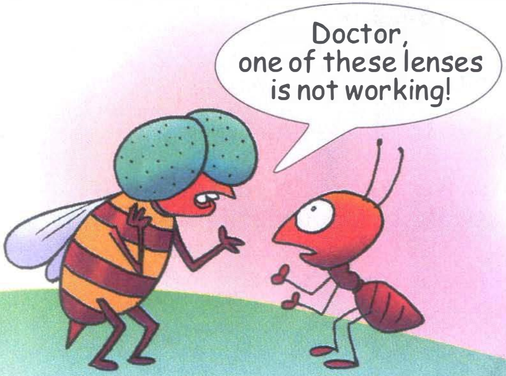
What are compound eyes?

Human beings and most animals have simple eyes, but some insects and marine animals have compound eyes.

Compound eyes are different from human eyes. Human eyes have a single lens for each eye, while compound eyes have many lenses.

Each unit has its own surface area, lens, and optic nerve fibre. Each unit receives light from a small part of the animal's field of view. The animal's brain combines these views into a single image.

An insect's compound eyes bulge out, and have a wide field of vision. The lenses in compound eyes can't change focus, so insects can't see things that are far away. The compound eye is very good at seeing things nearby, and detecting motion, which is why it is so difficult to swat a fly!

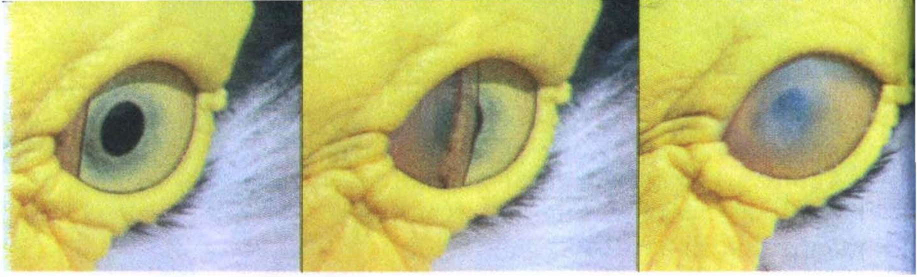

Doctor, one of these lenses is not working!

STAR FACT

Auroras

The word 'aurora' means 'dawn' in Latin. Auroras are spectacular displays of light seen in the sky over the Polar Regions. They are caused when tiny electrically charged particles from the Sun collide with the atoms in the Earth's atmosphere.

Aurora



A Bird's Third Eyelid.

How are our eyes protected?

Our eyelids snap shut when something moves suddenly in front of our eyes. This swift reflex is the body's way of protecting the eyes from injury.

Animals too, protect their eyes in many different ways. Most birds have three eyelids. The third eyelid is a semitransparent tissue, called the nictitating membrane.

In water birds, the third eyelid has a clear, goggle-like lens which improves the ability of the eye to focus under water. Birds also have long thin feathers over their eyes that act as eyelashes to keep out dust.

Desert animals too, have long eyelashes for protection against sand storms. Snakes and fish have no eyelids- their eyes are protected by a glassy coating.

STAR FACT

Protection for the Retina

The pupil is a tiny hole in front of the iris that controls the amount of light entering the eye. This is important, because too much light can cause damage to the retina.

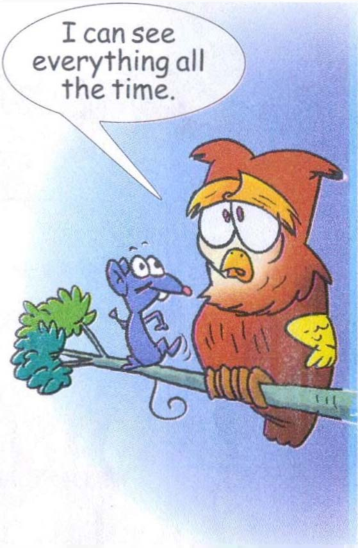
Why are some animals able to see at night?

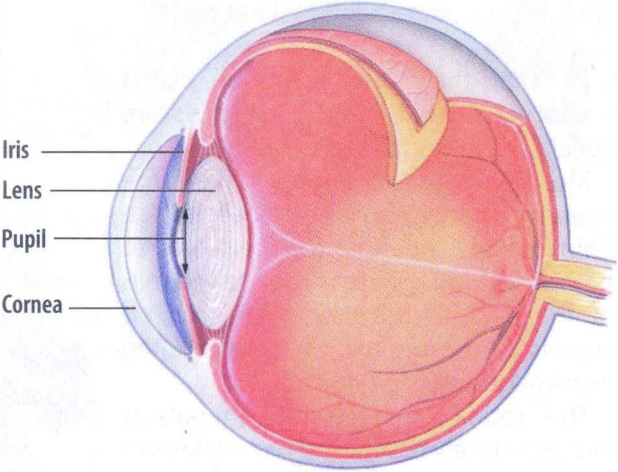
Animals that hunt at night are called nocturnal animals, and their eyes are specially adapted to see in darkness.

Most nocturnal creatures have large eyes, with wider pupils and larger lenses. This makes it possible for their eyes to gather enough light to stimulate the cells at the back of the retina, which send signals to the brain that are translated into images.

The retina of nocturnal animals is almost entirely composed of cells known as rods, that are sensitive to light. In nocturnal animals, cones are absent or almost absent, leaving them with virtually no colour vision.

Some animals have eyes that glow in the dark. This is because they have a special adaptation for night vision called the tapetum.


I can see everything all the time.



Why is the lens of the human eye amazing?

Light enters your eye through a central opening known as the pupil, which changes size depending on the amount of light.

Why do the eyes of animals tell us a lot about them?

Most animals – and Man- have two eyes. Some animals have compound eyes- but there are also animals with one eye, three eyes, and even eight eyes!

The freshwater crustacean cyclops has just one black or red eye in the middle of its head. The tuatara, which lives only in New Zealand, has three eyes. Some spiders have eight eyes that give them a near 360-degree view of the world.

Predatory mammals have eyes in the front of their heads, with powerful eye muscles.

The coloured area around the pupil is called the iris, and it controls the size of the pupil. The part of the eye that allows us to focus on different things is known as the lens.

The lens of the human eye is truly amazing. It can change shape so that we can focus on objects at various distances. The lens consists of about 2,200 infinitely fine layers, which lie on top of one another, like the skins of an onion.

The lens in the eye, unlike the glass lens of a camera is not rigid- it is, in fact, highly pliable.

An animal that is preyed upon by many enemies has its eyes out on the sides of its head, and each eye has its own field of vision. In fact the eyes of an animal tell the story of the creature's life, its sources of food, its habits, its fears, and the history of its species.

Dog's Vision

Until recently, it was thought that dogs didn't see any colour at all. Recent studies now show, however, that dogs can differentiate between red and blue and can even pick out subtle differences in shades of blue, and violet.

Why are we able to see colour?

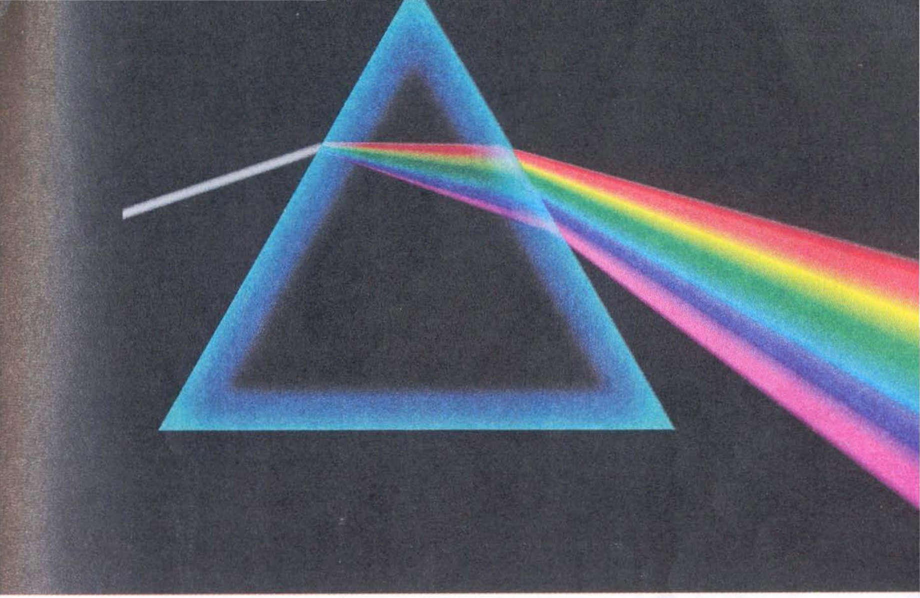
The retina of our eye is covered by millions of light-sensitive cells, some shaped like rods, and some like cones.

There are three types of cone-shaped cells, each sensitive to the long, medium, or short wavelengths of light which represent the colours red, green, and blue. These cells, working in combination with connecting nerve cells, give the brain enough information to interpret and name colours. In short, the human eye and brain together, translate light into colour.

STAR FACT

Night Vision

People who have to work in the dark often wear night vision goggles. These goggles are designed on the principle that even in pitch darkness, there is some reflected light, which we cannot normally see. Moreover, all objects give off 'heat' energy, which is not visible to the human eye. Night vision goggles are designed to collect and amplify all those tiny bits of available light so that our eyes have enough light to see in the dark. This is called image enhancement technology. The other technology used in night vision equipment is called thermal imaging. It takes advantage of the infrared light given off by objects, which is not visible to human eyes.



Dispersion of White Light through a Prism

How did Newton explain what white light is?

In 1665, Sir Isaac Newton was conducting experiments in a prism. He discovered that when a beam of light passes through the glass, it always 'split' into the same band of red, orange, yellow, green, blue, indigo and violet colours.

When the beam is passed through a second prism, the colours recombined and made white light. Newton's explanation is that ordinary light, or white light as it is also called, is made up of the seven colours that we see in the rainbow, each of which has its own wavelength.

When this ray of light passes through the prism, it is bent by the sharp edge of the prism, and so it splits into the different wavelengths that go in different directions- which is why we see a band of different colours. When this band passes through a second prism, the rays are bent back to their original shape, and the different colours come together once again to emerge as white light.

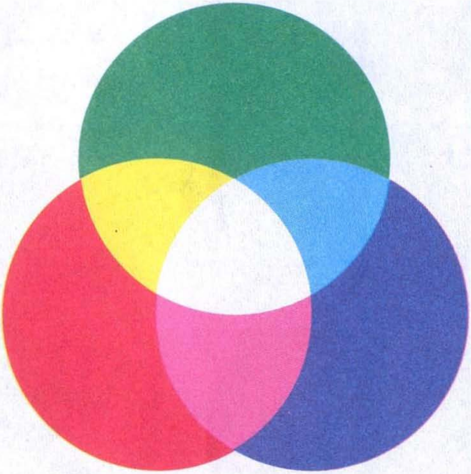
What are primary and secondary colours of light?

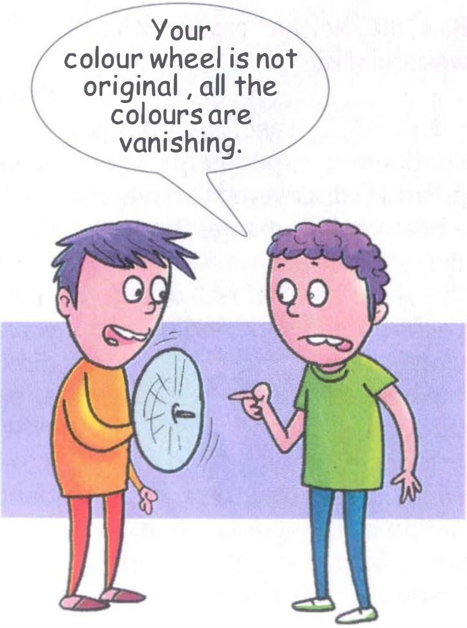
White light consists of seven distinct colours- red, orange, yellow, green, blue, indigo, and violet.

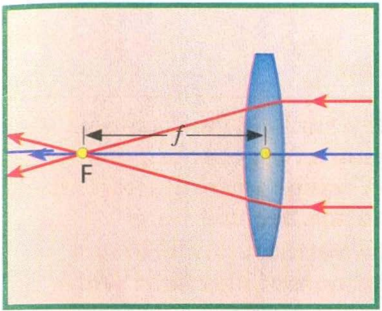
Of these seven colours, the human eye has receptors for only three- red, green, and blue. These three are called the 'primary colours' of light.

The brain interprets other colours by combinations of these three colours to form secondary colours. The primary colours must be combined in the correct amounts so as to form the secondaries.

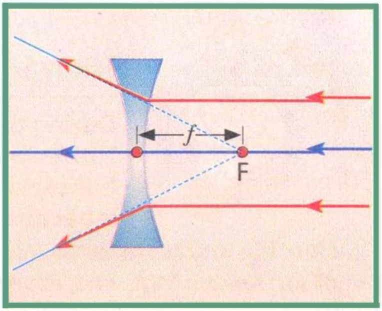
Additional colours are formed by varying the quantities. For example, purple may be formed by using considerably more blue light than red. Conversely, using more red than blue will form pink.




Your colour wheel is not original, all the colours are vanishing.



Convex Lens



Concave Lens

Why are convex and concave lenses important in optics?

A lens is a device that transmits or refracts light. The surface of the lens can be convex, in which case it bulges outwards, or concave, which means that it curves inwards.

Convex lenses are thicker at the middle. Rays of light that pass through the lens are brought closer together. They are said to converge, and so, a convex lens is also called a converging lens.

Concave lenses are thinner at the middle. Rays of light that pass through the lens are spread out, and are said to diverge. So, a concave lens is also a called diverging lens.

Lenses are important in a variety of optical instruments, ranging from microscopes and telescopes, to spectacles for young and old.

Origin of 'Lens'

A convex lens is flat and round, with sides that bulge outwards. It resembles a lentil seed from which the word 'lens' originates.

STAR FACT

Tricky Sunlight

During the day, sunlight looks golden. However, as sunset approaches, the light takes on orange and red hues. This is because the rays become more slanting and have to travel sideways through more layers of air. As this happens, more and more of blue light, which has a shorter wavelength is absorbed and only the colours with longer wavelengths like orange and red are seen.

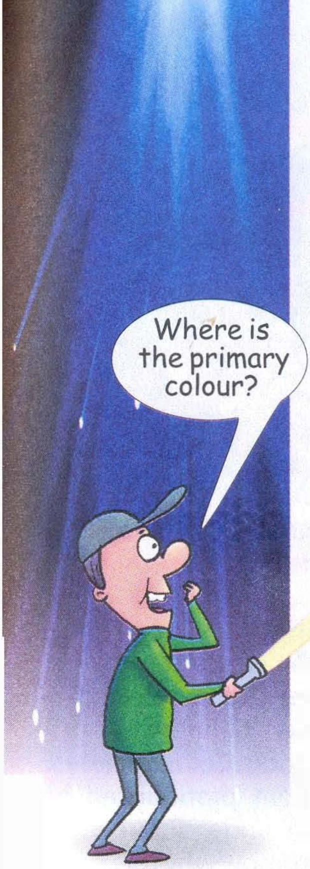
Why are lenses important in lighthouses?

A lighthouse is a tall, tower-like building with a powerful signaling lantern at the top. The beam of light from the lantern sweeps across the sky at regular intervals in all directions, guiding ships at sea. The beam is concentrated, and focused by special lenses, so that it can travel a very long distance.

The first lighthouse optics, that was designed by the French inventor Augustin -Jean Fresnel, combined highly polished prisms with an array of lenses that captured light and funneled it back into a main beam. This light could be seen for more than 32 kilometres.

Many of today's lighthouses have a system of rotating lenses, and the newer ones flash off and on as a way of conserving energy.

A Lighthouse


Where is the primary colour?

What are the additive primary colours of light?

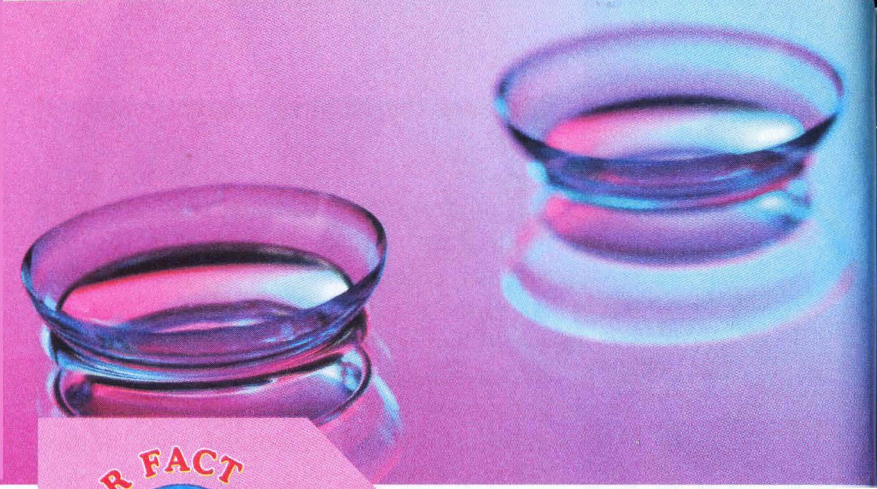
Primary colours are those that cannot be made from mixing other colours. Instead, primary colours are the source of other colours.

Additive primary colours are the primary colour elements that make up white light. They are different from the primary colours that are mixed for painting. The additive primary colours are red, green, and blue, commonly called RGB. By additively mixing the colours red, green, and blue in varying amounts, almost all other colours can be produced.

For example, when a green light and a red light are shone together on a wall, the result is a yellow light! In various combinations, these three colours will also make almost any other colour. However, when the three primaries are added together in equal amounts, white is produced.

Improving Vision

For almost 700 years, spectacles have helped people with poor eyesight to see better. Spectacles with convex lenses help people with long sight, to see nearby objects more clearly. Concave lenses are used by people with short sight, so that they can see far off objects more clearly.



STAR FACT

Contact Lenses

A contact lens is a thin lens that is placed directly on the eye to improve vision. These lenses float on a film of tears in front of the cornea and are today made of plastic or silicon. Like spectacles, they are used to correct a variety of vision problems including myopia and astigmatism.

Why do colours in fabrics appear different under fluorescent light?

In our daily lives, we often notice that the colour of clothing as seen under fluorescent lights indoors looks different under sunlight outdoors. Colours like red are much more pronounced in sunlight than under fluorescent lights. Do you know why this is so? Like sunlight, fluorescent light is also white light, and it is also made up of many different wavelengths. But the wavelengths in fluorescent light are different from those in sunlight. So, when these wavelengths are reflected to our eyes, we get the feeling that there is something a bit different about the colour of our clothes.

CURIOUS FACT

Achromatic Lenses

An achromatic lens has two lenses made of different types of glass. One splits the colours, and the other brings them together again. The purpose of this lens, invented in 1733 by Chester Moor Hall, was to prevent colour separation.

Diamond

STAR FACT

Why Diamonds Glitter

Diamonds behave like prisms. When light passes through a cut diamond, it is bent into different wavelengths, and the colours separate, and then are reflected back out. Since a diamond's shape is different from a prism's, the colours don't appear in straight rows, but more like shards of colour as in a kaleidoscope. As a diamond moves, the shards of colours change like in a kaleidoscope, making the diamond glitter.

Why is the history of telescope an interesting one?

In 1609, the Italian scientist Galileo first peered through his small homemade telescope at the stars. Since then, telescopeshaveincreased our knowledge of the heavens by leaps and bounds.

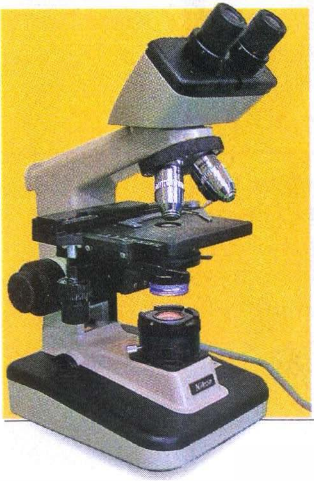
The first telescopes used to peer into space were refracting telescopes. This means that you would look straight through the telescope from one lens to the other, to the image you were looking at. However, the lenses used in these telescopes were not the best, and the images were blurry. It was soon discovered that if

This time, I will win!

Why is the history of microscope interesting?

It was the Romans who first invented glass, and discovered that if a piece of a certain type of glass that was thick in the middle and thin on the edges was held over an object, it would make the object look larger. This was the first primitive 'lens'.

The early lenses were called magnifiers or burning glasses. In the 13th



Microscope

the telescope lenses were further apart, they would show a clearer image, and then telescopes began to get really long.

In the 1680s, Isaac Newton designed a successful reflecting telescope. This type of telescope had a mirror inside that would reflect the image to a focus point. Newton found that this made the images of space much clearer to the viewer. Since that time, humans have raced to build bigger and better telescopes.

Nowadays, there are many different types of telescopes. There are radio telescopes, x-ray telescopes, infrared telescopes, gamma ray telescopes and ultraviolet telescopes.

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century, spectacle makers started producing lenses to be worn as glasses.

Sometime about the year 1590, two Dutch spectacle makers, Zaccharias Janssen and his father Hans invented the compound microscope - which is a microscope that uses two or more lenses.

Galileo, the great Italian scientist, improved the microscope by adding a focusing device to it.

Antonie Van Leeuwenhoek of Holland found that by grinding and polishing, he was able to make small lenses with great curvatures. These rounder lenses produced greater magnification. His new improved microscope was able to see things that no man had ever seen before, and he is often called the 'Father of Microscopy.' Robert Hooke, an Englishman, also improved microscopes.

What are filters, and why are they important?

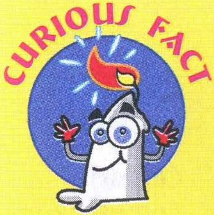
As well as adding colours to produce new ones, colours can also be subtracted from one another by using special filters that only allow certain wavelengths of light to pass through. For example, if you pass white light through a red filter, then red light comes out through other side. This is because the red filter only allows wavelengths of red light through. The other colours- or wavelengths- of the spectrum are blocked.

In our daily life, different types of glasses can act as filters. They are known as photochromatic glasses, and they are used most commonly in the sunglasses that we wear.

The ozone layer, high up in the atmosphere, is a filter that blocks out wavelengths of ultraviolet light that are harmful to us. A pigment called melanin in our skin also acts as a filter against the damage that too much sunlight can cause.

Galileo's Telescope

Galileo's earliest telescope contained two lenses-a convex lens, and a smaller concave eyepiece lens. Galileo used his telescopes to look at the Moon, the planets, and the stars.



Hooke's Microscope

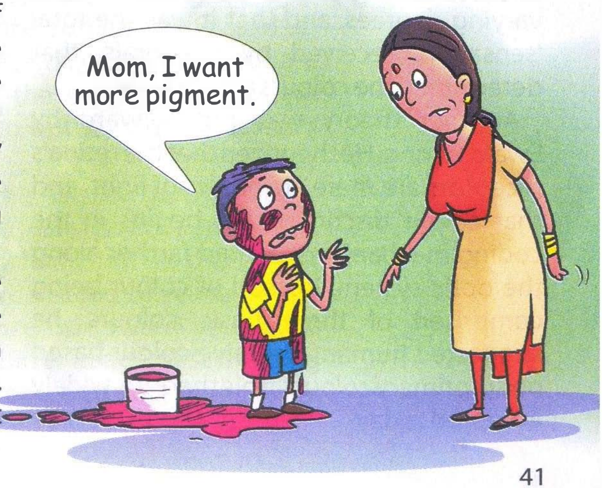
Robert Hooke made compound microscopes containing two, or sometimes three lenses. In 1665, he looked at a sliver of cork through his microscope and noticed some 'pores' or 'cells' in it. He was the first person to use the word 'cell' to describe the basic unit of life.

What are pigments?

Pigments are substances that are responsible for giving colour to an object. We know that the primary colours of light are red, green, and blue. The primary colours of pigments are different- they are red, blue, and yellow. Secondary colours are produced by mixing the primary colours.

Pigments are found both in the living world and in manmade materials. The natural pigment present in a living organism plays a very crucial role in its daily life. The most common pigment present in human and animal's skin is known as melanin, which gives protection from sunburn.

The earliest pigments used by people were those that occurred naturally, such as ochres and iron oxides which have been used as colorants. Today, synthetic pigments are widely available.


Mom, I want more pigment.

Hermann Von Helmholtz

Ewald Hering

Why do we see colour?

Renowned researchers, Thomas Young and Hermann von Helmholtz, contributed to the trichromatic or three colour theory of colour vision. According to Young, we see colour because of the actions of three different receptors.

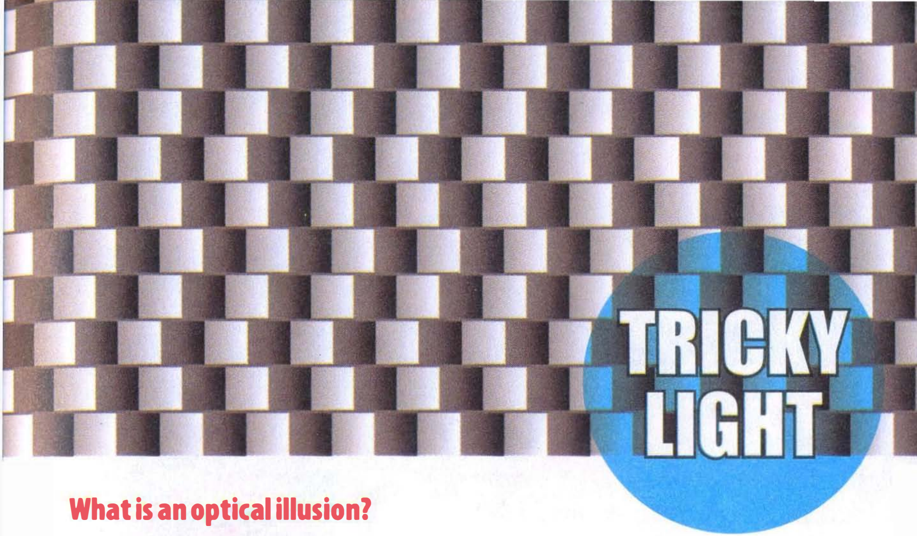
Helmholtz explained that all three types of receptors reacted to all colours, but in varying degrees, and that it was the total 'sensation' received by the brain that determined the colours actually seen.

Another theory was put forward by Ewald Hering. He theorized that the retina's receptors are mere absorbers of light, and that colour discrimination begins in the coding mechanisms located farther along the optic system. Instead of colour being comprised of three basic colours, he suggested humans perceive colour based on six primary colours. This theory is widely accepted today.

STAR FACT

Colourful Communication

The octopus, cuttlefish, and squid have special cells that are filled with different coloured pigments. The size of these cells can be controlled by the brain. For example, by making all the red cells large, and all the others small, the animals can produce a red colour over its body, to signify that it is angry.



TRICKY LIGHT

What is an optical illusion?

An optical illusion is a way of tricking the brain to see something that may not be there.

The human brain puts images together because it has learned to expect certain things-and sometimes, the data gets confused. For example, on a sunny, hot summer day, when you happen to be on a long, straight road, take a look at the surface of the road up ahead of the car. It often appears that there are pools of water on the road. What you are actually seeing is an optical illusion called a mirage.

The reason for this illusion is that under certain conditions, usually on hot sunny days, light beams bend when they hit the hot air close to the ground. Instead of reaching the ground, they bounce up toward your eyes. What you see is a mirror image of something on the ground, a reflection that looks like a puddle.

How is a rainbow formed?

Rainbows appear magical, but there is a simple explanation for their sudden appearance and breathtaking beauty.

Simply saying, a rainbow occurs when sunlight is reflected and refracted by the water droplets in the atmosphere. The lower the Sun is in the sky, the higher the arc of the rainbow will be.

How is a rainbow made? Well, you know that sunlight looks white, but it's really made up of different colours...red, orange, yellow, green, blue, indigo, and violet. When white sunlight passes through rain drops, the raindrops act like tiny prisms. They bend the different colours in white light, so the light spreads out into a band of colours – red, orange, yellow, green, blue, indigo and violet - the colours of a rainbow.

CURIOUS FACT

Upside down Rainbows

Very rarely, we can see an upside down rainbow. This is an unusual phenomenon caused by sunlight shining through a thin, visible screen of tiny ice crystals high in the sky.

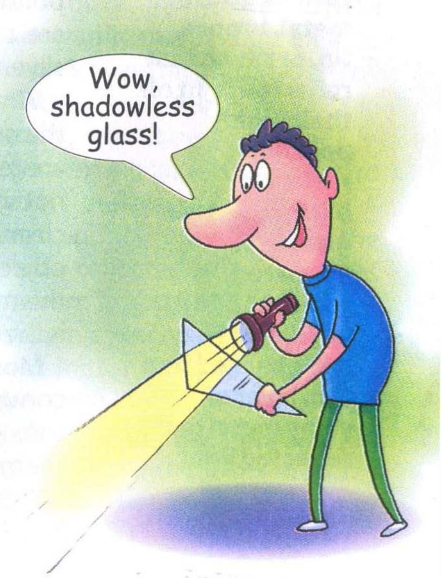
Invisible Fish

The hatchet fish found only in the deep sea, has sides that are covered with large silver scales that act like mirrors, and two rows of light-producing organs on its underside. The effect is to make the fish invisible to its enemies.

What are transparent and opaque substances?

When a beam of light hits an object, three things can happen. It will either pass through it, be reflected off it, or be absorbed by it. Transparent materials are those that allow light to pass through them. We can see clearly through transparent materials like water and glass. Sometimes, however, the surface of even a transparent material such as glass can be reflective, and light will bounce off it. Some materials known as translucent materials allow light to come through, but we cannot see through them.

Objects through which light cannot pass are called opaque objects. When a ray of light hits an opaque object, it will be reflected in all directions, and the light is said to be scattered. The reflected light reaches our eyes, and allows us to see the object. A shadow will be cast behind the opaque object, where the light cannot reach.


Wow, shadowless glass!

STAR FACT

Old Mirrors

The mirrors used by the ancient Greeks and Romans, were simply slightly convex discs of metal, bronze, tin, or silver, that reflected light off their highly polished surfaces. Mirrors of clear glass first appeared around 1300 AD in Venice. They were backed by a thin layer of shiny metal that reflected light.

18th Century Vermeil Mirror

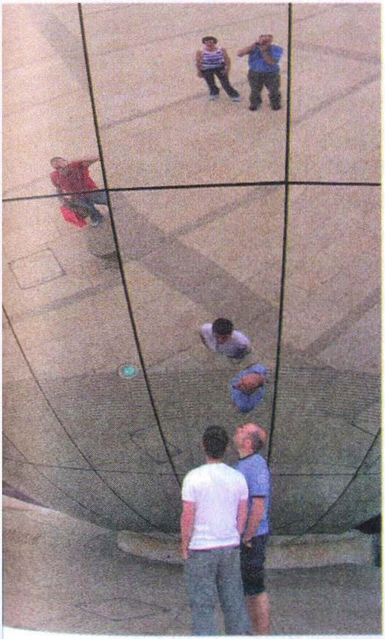
What are mirrors?

Mirrors are surfaces that show you exactly what you place in front of them. They were originally made of polished metal, but nowadays, they are made of glass with a metallic or silvery coating.

When light rays hit a mirror, because the surface is smooth and shiny, they are reflected in the same direction, and not scattered at all. As a result, you get a clear image that is an exact copy of the object. The image in a mirror is inverted- this means that the left side of your face is the right side of the image.

Most mirrors are flat, but there are convex mirrors and concave mirrors too. Convex mirrors make the image seem smaller, so that a larger area can be seen. Concave mirrors, on the other hand, make the image seem larger.

Image in a Convex Mirror



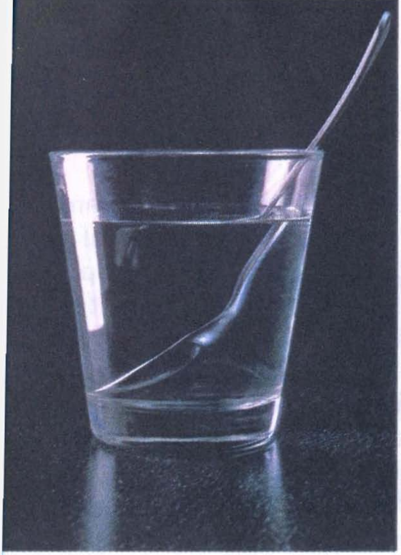
Reflections in a Convex Mirror

Why are concave mirrors different from convex mirrors?

A concave mirror has an inward curved surface, like the inside of a spoon. Because of its curved shape, light rays are focused at a point in front of the mirror's surface.

Depending on where an object is placed,a concave reflecting surface can reduce and invert an image, or enlarge an image. So, if you stand in front of a concave mirror, you will notice that thatthe reflected image is reduced and inverted. If you move closer, your image turns over, and becomes enlarged. Concave mirrors have many uses. These include vanity mirrors that enlarge a person's face, the mirrors used by dentists, and those used in reflecting telescopes.

A convex mirror has an outward bulging reflecting surface. A convex surface only reduces the size of a reflected image- it does not invert it, regardless of where an object is placed in front of it. A convex mirror allows a wider area to be seen, and its many uses include rearview mirrors in automobiles, and mirrors in stores that are used for security purposes.



Glass and Spoon with
View of Refraction in Liquid

How's this ? Permanently bent!

Why does a spoon appear bent when placed in a glass of water?

Place a spoon in an upright position in a round glass of water. Now, move it slowly from the middle of the glass to the side. You will see that the spoon appears to get bent or broken. This illusion occurs because of a phenomenon called the refraction of light.

Refraction takes place when light passes at an angle from one transparent medium to another, for example, from air to water.

We know that light travels in a straight line, but when a ray of light hits the water at an angle, its speed changes. This causes a change in direction. So, the light is bent- and then continues in a straight line.

When the spoon is straight up in the glass, it appears straight, because when light hits the water square on, it will pass straight through, and will not be refracted or bent. So, there is no distortion. However, when we move the spoon sideways, the light from the spoon hits the water at an angle so it is refracted or bent, and the part of the spoon under water appears in a different location. The result is the illusion of a bent spoon.

CURIOUS FACT

Objects in Water

An object that is seen in water is actually a virtual image of the object. Though the rays of light are bent as they travel from water to air, our eyes continue to follow the rays as though they have travelled in a straight line. So what we see is not the actual object, but its image.

Willebrord Snel Van Royen

Who discovered refraction?

The Egyptian geographer Ptolemy who lived between 90 and 168 AD tried to explain the phenomenon, but was not entirely successful.

However, the actual law of refraction was discovered in the early 1600s by a Dutch mathematician Willebrord Snel Van Royen. He explained that when light travels from one medium to another, it generally bends, or refracts. The bending is caused by the differences in density between the two substances, which in turn affect the speed at which light travels through them. Snel's explanation of refraction is still known as 'Snell's Law.'

CURIOUS FACT

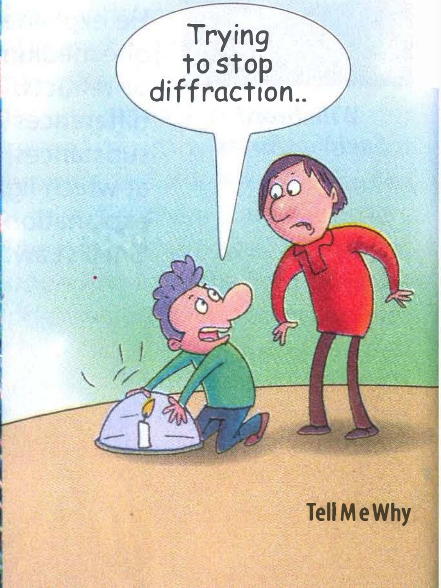
Peacock's Feathers

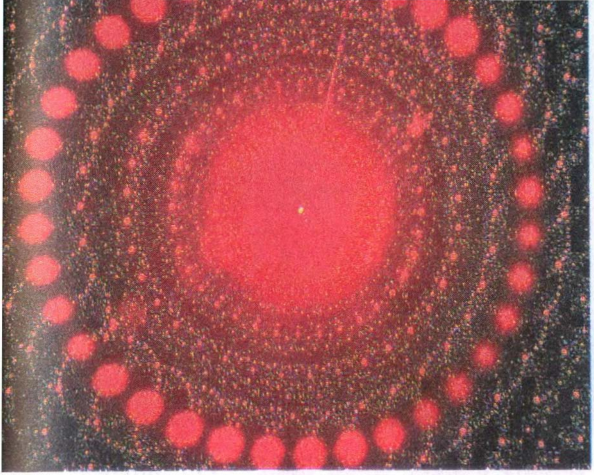
The many colours of the peacock's feather, which usually include shimmering greens and blues, are the result of a phenomenon called interference. Interference is the reflection of light on each feather's tiny, bowl-shaped indentation, which reflects the light and causes the colour to shimmer.

What is diffraction?

Diffraction is the spreading out of waves, such as those of water, sound, radio, or light, as they pass around an obstacle, or go through an opening. If you screw your eyes up, and look at a streetlight in the dark, as your eyes close, the light seems to spread out in strange stripes as it squeezes through the narrow gaps between your eyelashes. The tighter you close your eyes, the more the light spreads- this is because of the diffraction of light.

The phenomenon of diffraction was first recorded by


Trying to stop diffraction..

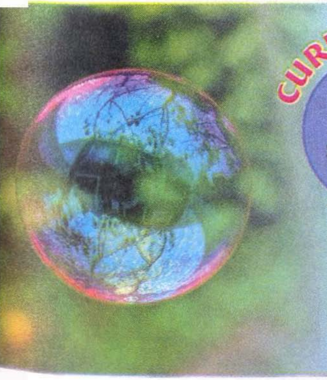


Optical Diffraction Pattern of Laser

Thomas Young

an English physicist, Thomas Young, in 1801. He noticed that light rays spread out, or were 'diffracted', when they passed through a very small slit. Light waves may be diffracted only under certain conditions. For example, light waves ordinarily will not turn corners, but they will be diffracted when they pass through tiny openings.

The diffraction pattern, the pattern of dark and light created when light bends around an edge, shows that light has wavelike properties.



CURIOUS FACT

Soap Bubbles

A soap bubble reflects a spectrum of beautiful colours when illuminated by natural or artificial light sources. This is because the light is reflected from two surfaces- the inner and the outer-of the bubble.

Why do rainbow-like colours appear when light strikes oil that is floating on water?

Oil Spill on a Road

When oil is poured on water, it spreads out to form a very thin film on the surface of the water. However, this film is of varying thickness. In some places, it is literally a molecule thick, whilst in other places, it is much thicker.

When light passes through the oil, some of it is reflected back off the different layers of oil, whilst some carries on, and is reflected off the surface of the water lying below. Because the light waves have now travelled different distances before being reflected, they mix together, producing a spectrum of colours. As a result, a rainbow-like colour pattern is shown on the oil surface, and this phenomenon is called thin-film interference.

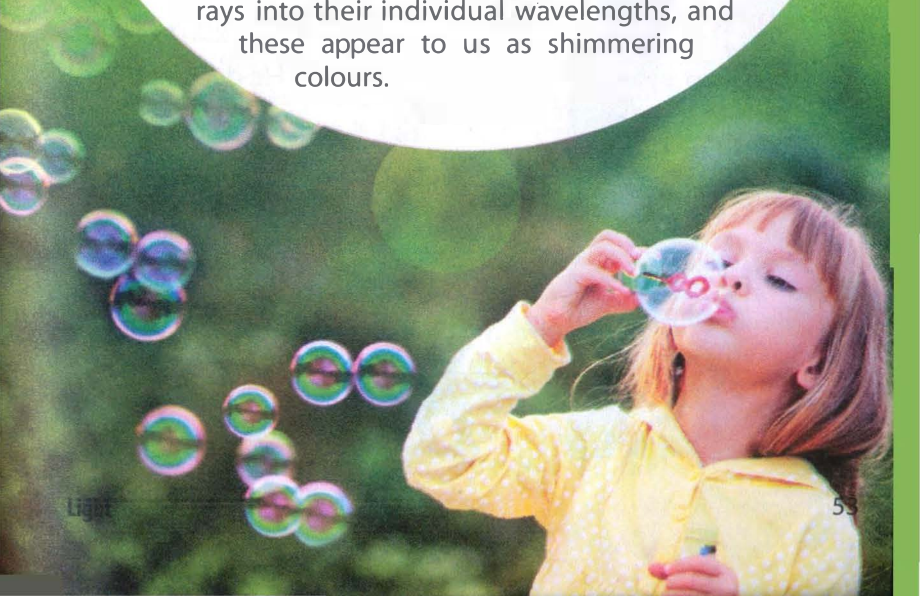
The great scientist Thomas Young in 1801 put it in a nutshell when he described thin film interference as the interaction of light waves reflected from the top surface of a thin film, with those which penetrate the film, and are reflected from the back surface of the film.

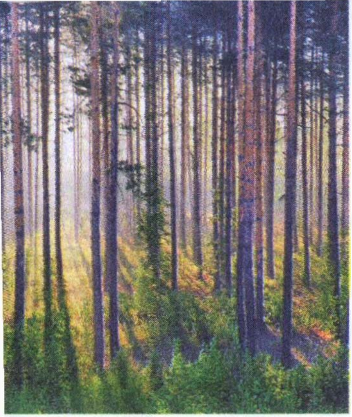
Why do soap bubbles shimmer?

Don't you love to watch and catch soap bubbles as they float in the air? Whether they are blown from a plastic pipe, or lathered between your hands, the bubbles seem to shimmer with colours that shift between blue, red, and purple as they encounter even small amounts of light.

The reason they do so is because of the properties of light. When light rays move from one transparent medium to another- in this case, from air to the bubble- some rays go through, and some rays bounce back, or are reflected. These light rays bend at the point where air meets the bubble.

When light bends, it is called refraction- and refraction is what causes soap bubbles to be coloured. The more the light ray bend, the blue rays from the spectrum will become visible to the human eye. Smaller bends make the red parts of the spectrum visible. In effect, the surface of the bubbles acts like a prism that separates the various light rays into their individual wavelengths, and these appear to us as shimmering colours.



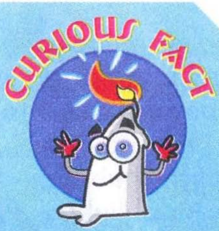


Morning Sun in a Foggy Forest

What is polarization?

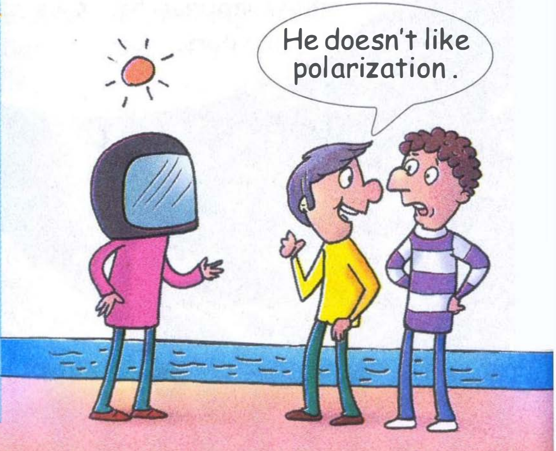
Everyone has experienced the discomfort caused by glare in intense sunlight. Very often, glare is caused by sunlight reflecting off surfaces like water, snow, or sand. Instead of diffusing the light in many directions, these surfaces absorb some of it, and reflect the rest- especially light waves that are horizontal.

Scientists call this selective reflection of horizontal light waves polarization. When you wear sunglasses, their lenses block out the annoying horizontal light with a tinted plastic filter set with tiny crystals that have been 'stretched' into a series of lines, like the slats of a picket fence. However, enough of vertical light gets through the filter to let you see well, and even read.



Coloured Shells

The inside of some shells have thin layers of hard mineral called nacre. Each layer reflects light, and the reflected rays interfere with each other to create silvery colours.


He doesn't like polarization.

Total Internal Reflection at the Air-Water Boundary

What is meant by TIR?

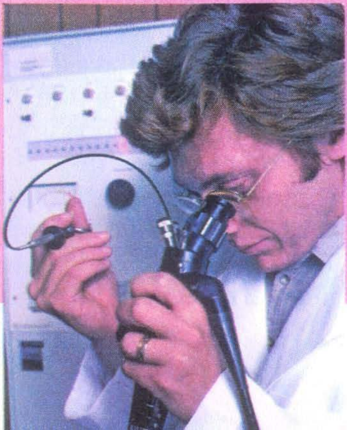
We all know that a diamond sparkles brightly. But do you know why? To begin with, a diamond is cut so that it has many surfaces at different angles to each other. It sparkles because light bounces to and fro off the inside of its many surfaces, and produces the flashes of light that we see. This is an example of total internal reflection, or TIR.

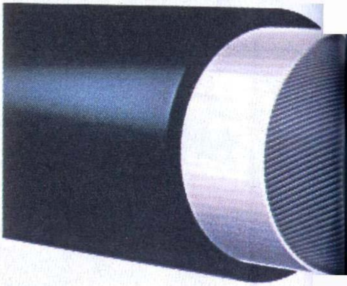
To understand TIR, we must understand that when light crosses a boundary between two transparent substances, it bends away from a line perpendicular to the boundary. As the angle of light hitting the boundary becomes sharper, the light bends farther and farther. Finally, it reaches an angle where the light is reflected back inside the material it is traveling through.

In other words, the light is completely reflected inside the substance, and not refracted. The reflection is the total internal reflection, or TIR.

Inside View

Doctors can now look inside our bodies by using an instrument called the endoscope. An endoscope typically employs two types of optical fibres. A central bundle of complex fibres transmits the image from inside the body, while an outer circle of simple fibres projects enough light inside the body cavity to make the image visible. Sometimes, a third set of fibres transmits a laser beam, which can be used to perform small-scale operations within organs or tissue.



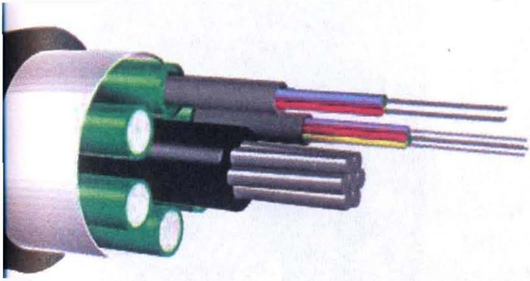


How do fibre optic cables work?

Fibre optic cables are bundles of extremely pure glass threads that have been coated in two layers of reflective plastic.

Light travels through the glass strands and continuously reflects off of the inside of the mirrored plastic coatings in a process known as total internal reflection.

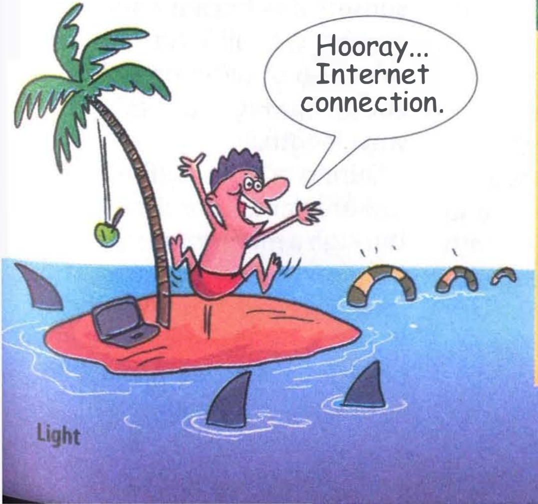
The development of flexible optical fibres has enabled light to be transmitted over long distances and apparently around corners. Optical fibres are ideal for seeing into places that are not easily accessible. They are also used to carry coded light



Fiber Optic Cable

signals over very long distances, and so, are important to the modern telecommunications industry.

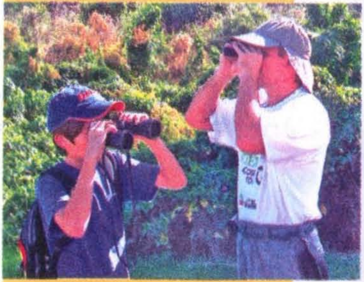
Optical fibres are rather like the nerves in our body. Both are very thin and each contain many hundreds of individual fibres bundled together. Each nerve fibre is designed so that the electrical signals they send to the brain cannot escape or change at all- in the same way that optical fibres do not allow light to change or escape at all.


Hooray... Internet connection.

CURIOUS FACT

Binoculars

Binoculars have two pairs of prisms so that light is sent back and forth as it is reflected four times. The prisms turn the image so that it is the right way round, and also the right way up. This makes it possible for binoculars to be shorter than telescopes.

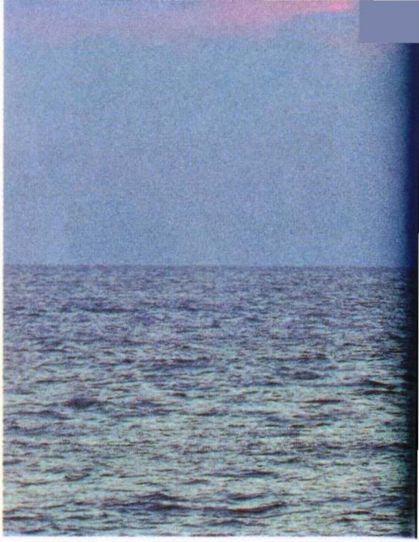


Why are fluorescence and phosphorescence useful?

Fluorescence is the the property of absorbing light of short wavelength and emitting light of longer wavelength. Fluorescence seen in the redness of rubies, in sunlight, in fluorescent markers, and in 'Day-Glo' or 'neon' colours. There are many other uses for fluorescence too. It is used in neon lights, highway lights, TVs, computers, microscopes, and paints.

There are numerous uses for phosphorescence in daily life. Apart from glow in the dark toys, phosphorescence is used for more sophisticated needs. Many watches are developed with phosphorescent materials on their hands so the user can tell the time in the dark.

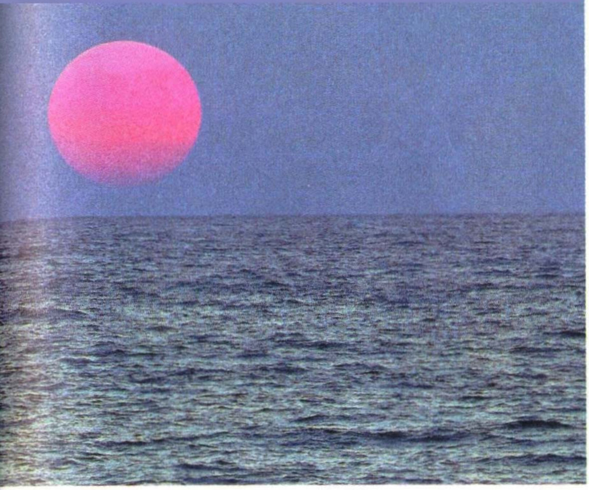
Phosphorescent substances are used in paints, on electric switch boards and sign boards. Emergency routes, doors, and stairways are often marked with these paints. These substances absorb sunlight during the day time, and use the stored energy to glow after dark.



Why does the Sun look red at sunset?

We have all enjoyed the beauty of glorious sunsets, when the Sun appears to be a fiery red. Why is the Sun, which is blazing white at noon, red at sunset? It is because sunlight or what we call 'white light' is made up of different colours, each having a different wavelength.

During a sunset, the sun's rays are slanting, and they pass through a much longer path in the lower atmosphere. The lower layers of the atmosphere have many more of the tiny particles called aerosols that



are suspended even in the cleanest of air.

Aerosols come from many sources like soil, salt from the ocean, plants, the burning of fossil fuels or vegetation.

As the lower layers of the atmosphere have more aerosols, their scattering effect is magnified. This results in more red light being scattered towards you than any of the other colours... and in blazing sunsets.

Tomorrow I will show you a blue Sun.

Ancient Fireworks

Fire was first produced by striking together pieces of either flint or iron pyrites. These minerals give off sparks when they are hit with something hard. Later, flint and iron pyrite were both used to ignite gunpowder in ancient rifles.

STAR FACT

Fire Box

When you strike a match against the matchbox, a chemical reaction produces a flame. Most matches and matchboxes have compounds of phosphorous that catch fire when being exposed to air. In fact, early matches used to catch fire without being struck, but this was dangerous. So, modern matchboxes use ' safety' matches that light only on being struck.

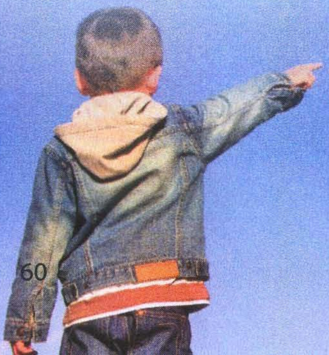
Why is the sky blue?

We know that sunlight or white light is made up of different colours, each having a different wavelength. As the light from our Sun shines into the atmosphere, most of the colours are able to reach the Earth's surface uninterrupted.

However, the Earth's atmosphere is filled with trillions of tiny dust particles, that are too small to be seen with the human eye, and that are the same length as the wavelength of blue light.

As a result, blue light is scattered, and bounces in every direction until it eventually reaches your eyes. For this reason, no matter what direction you look in the sky, it appears to be blue.

Though human beings had wondered for centuries why the sky is blue- and had tried to come up with many explanations- the correct explanation was first given by John Tyndall in 1859.

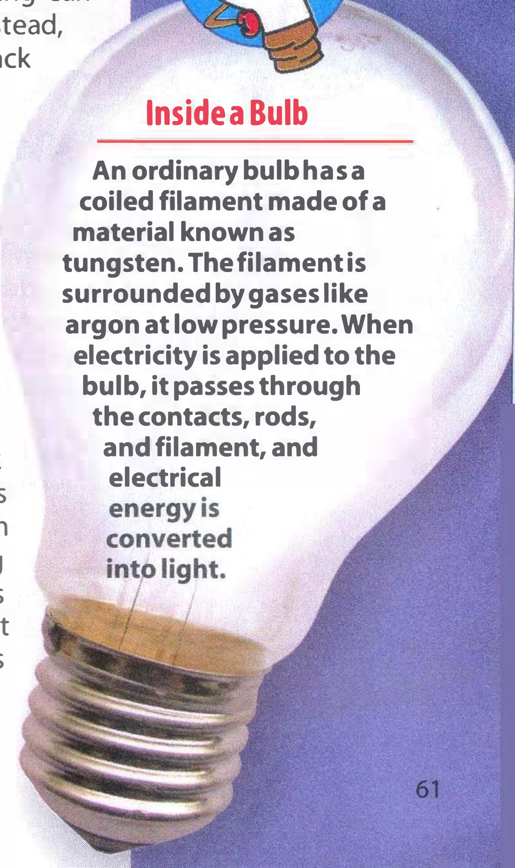


Why are black holes black?

Black holes are one of the most mysterious and powerful forces in the universe. They are formed when giant stars explode at the end of their lifecycle. This explosion is called a supernova. If the star has enough mass, it will collapse on itself, down to a very small size. Due to its small size and enormous mass, its gravity will be so strong that nothing can escape from it- even light. Instead, all light is absorbed, and a black hole is formed.

Black holes can grow incredibly huge as they continue to absorb light and mass around them. They can even absorb other stars. We can't actually see black holes because they don't reflect light, but scientists know they exist by observing light and objects around black holes. A simple way to put it is that a black hole is a point in space where something exists, but because of its extreme gravity, light cannot escape from it, and so, it is not visible under any conditions.

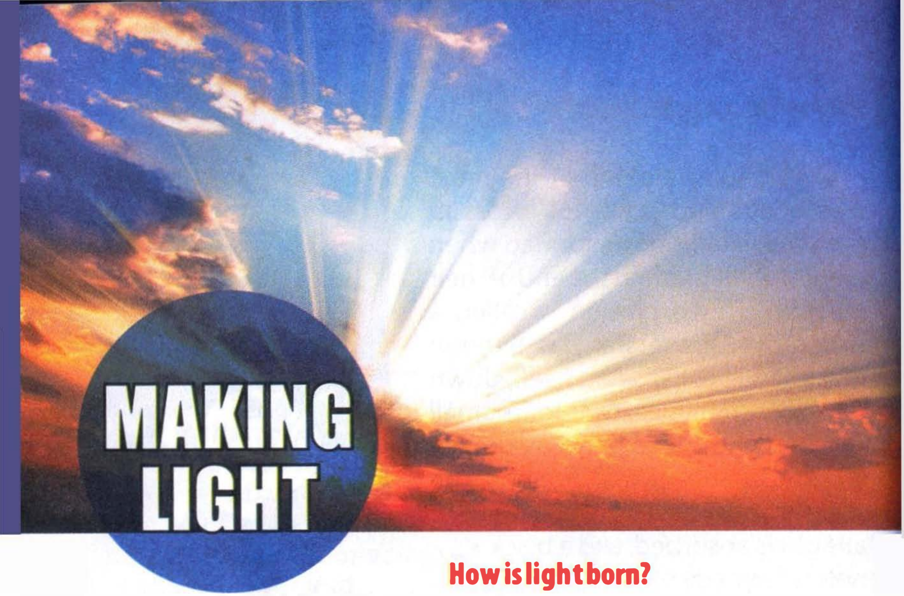
STAR FACT



Inside a Bulb

An ordinary bulb has a coiled filament made of a material known as tungsten. The filament is surrounded by gases like argon at low pressure. When electricity is applied to the bulb, it passes through the contacts, rods, and filament, and electrical energy is converted into light.

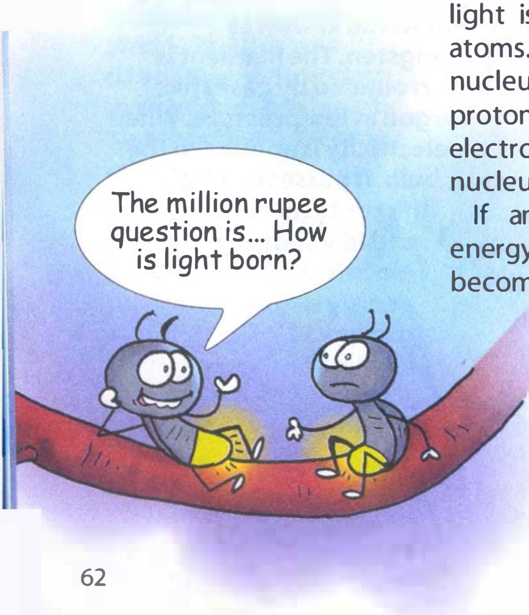
MAKING LIGHT



How is light born?

Whether light comes from the Sun, fire, a light bulb, or a firefly, light is created by the action of atoms. An atom consists of a heavy nucleus containing neutrons and protons, surrounded by a cloud of electrons orbiting around the nucleus.

If an electron is given extra energy, it will absorb the energy, become excited, and 'jump' to a higher level. As it does so, it gives off light energy in the form of photons. Electrons in different atoms give off light energy in different wavelengths that produce different colours.


The million rupee question is... How is light born?

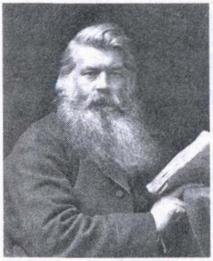
Why is the history of electric light fascinating?

For thousands of years, people all over the world have been fascinated by lightning.

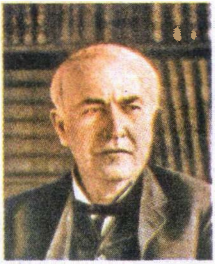
In 1752, a genius named Benjamin Franklin conducted an experiment to prove that lightning was caused by electricity. Throughout the next hundred years, many inventors and scientists tried to find a way to use electrical power to make light.

In 1800, Humphry Davy, an English scientist, experimented with electricity, and invented an electric battery. When he connected wires to his battery and a piece of carbon, the carbon glowed, producing light. This is called an electric arc.

Later, the English physicist Sir Joseph Wilson Swan demonstrated his new electric lamps in England. These lamps used a carbon filament inside a glass bulb to produce incandescent light. However, it was the inventor Thomas Alva Edison's lamp that became the first commercially successful incandescent lamp. In 1910, William David Coolidge invented a tungsten filament which lasted even longer than the older filaments. This incandescent bulb revolutionized the world.

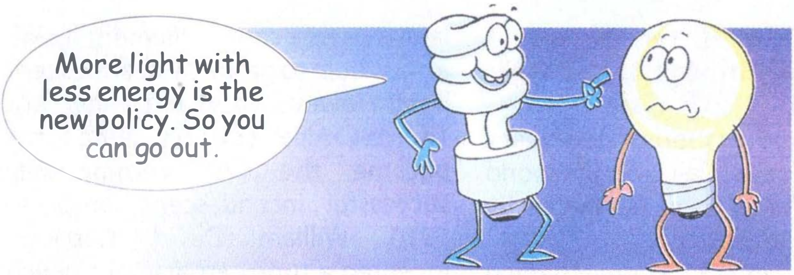


Joseph Swan



Thomas Alva Edison

Electric Lamps made by Swan (left) and Edison (right)

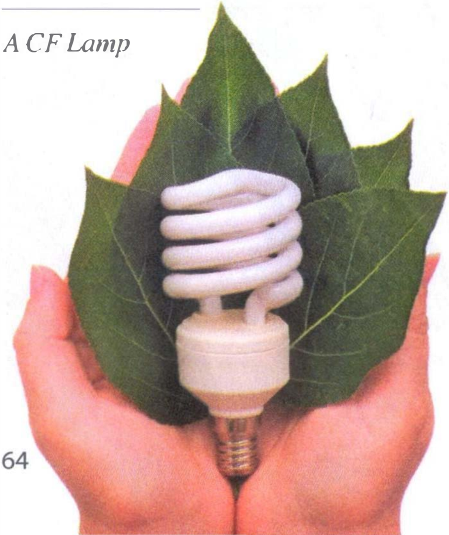

More light with less energy is the new policy. So you can go out.

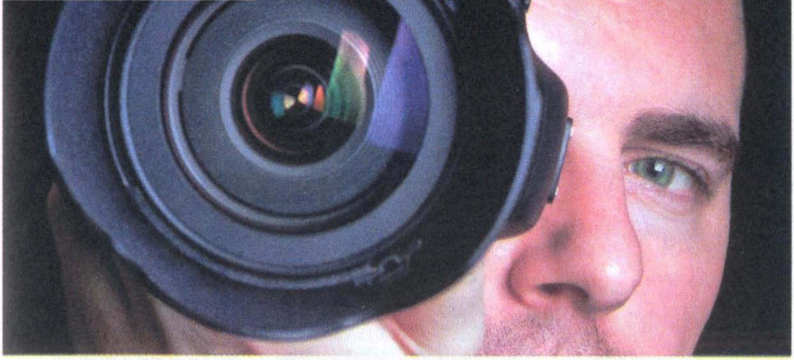
What are the different types of electric lights?

Today, there are many different types of electric lights. In incandescent light, a bulb glows when electric current heats up a filament placed inside a glass bulb, to produce a yellowish-white light.

In fluorescent lights, an electric current is passed through mercury vapour inside a glass tube. The vapour gives off UV light that is absorbed by phosphor powder coated on the inside of the tube, to produce a visible blue-white light.

Another type of lighting is strip lighting. In this case, an electric current flows through a gas that is under low pressure. The gas gives off ultraviolet light, and this strikes a phosphor coating, making it fluorescent, so that it produces light. The colour of the light depends on the type of gas that is used. Alternatively, metal vapours can be used instead of a gas. For example, mercury vapour produces a blue light, while sodium vapour glows yellow. Sodium vapour lights are sometimes used in street lighting.


A CF Lamp



Why is a camera similar to a human eye?

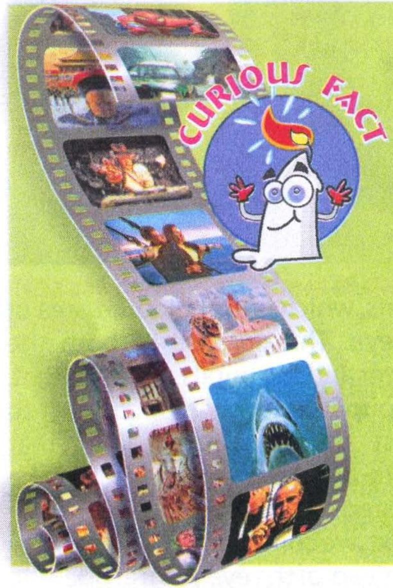
The human eye is a wonderful instrument that relies on refraction and lenses to form images- and a camera is similar to it in many ways. The shutter in a camera has the same function as the pupil of the human eye. The pupil is the tiny opening at the centre of the iris, which is the coloured area of the eye. The purpose of both the shutter and the pupil is to let in light. The pupil can expand or contract to adjust the amount of light that enters- and a camera's shutter can be adjusted too.

Next, we come to the cornea which is the 'cap' of the eye. It is transparent, sits at the front of the eye, and has a spherical curvature. The lens of a camera is also transparent as it is made of glass. It too is located in the front of the camera, and has a

STAR FACT

Swan's Lamp

Swan's lamp had a carbon filament inside a glass bulb. When a current was passed through the bulb, the filament glowed. Swan's house in England was the first in the world to be lit by a light bulb, and the world's first electric-light illumination in a public building was for a lecture Swan gave in 1880.



Negative to Positive

William Fox Talbot was one of those who pioneered the technique of making photographs in the 1830s.He soaked paper in a chemical called silver chloride that darkens when exposed to light. When light fell on the paper, it produced a negative image of the object before it. By using the same process to copy the negative, a positive print was obtained.

spherical curvature. The lenses of both the eye and a camera can focus and project an upside down image of an object before them.

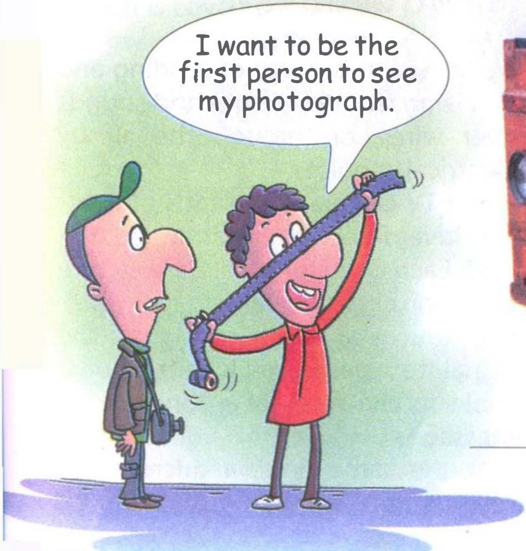
In a camera, film is used to capture an image. In the eye, the image is focused on the retina, which in turn, converts the image to electrical impulses and sends the information along the optic nerve to the brain.

This camera may help you.

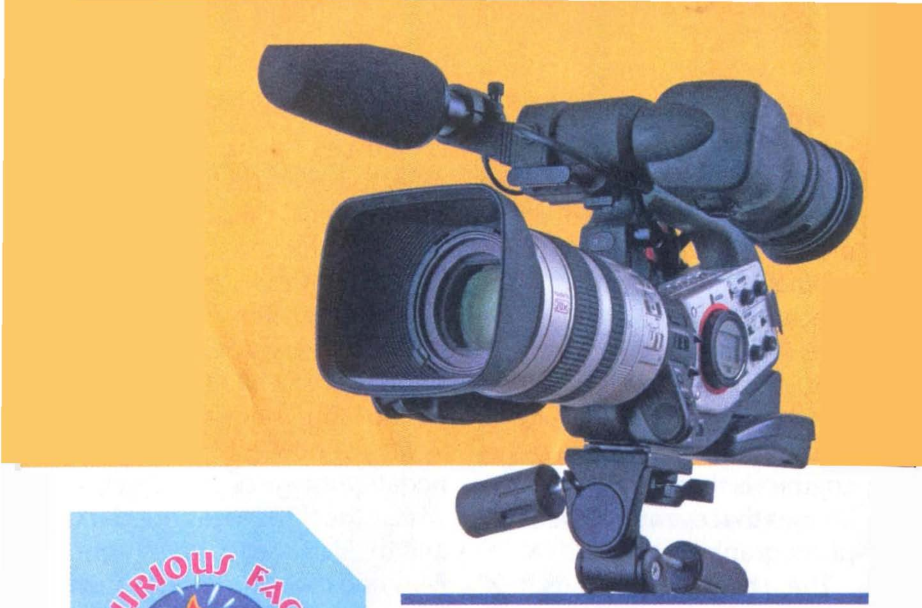
How do we get photographs?

A photographic film is an encased roll of celluloid, a thin plastic sheet. Both sides of this celluloid are treated with special chemical blends. One side is coated with chemicals that aid the development of film negatives, while the other is coated with multiple layers of chemicals that help to form the images that eventually become photographs.

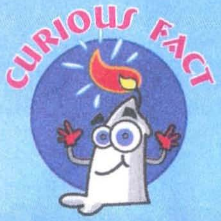
The chemical coatings that allow the creation of images on film are predominantly made up of silver halide crystals. When the shutter of the camera is pressed, light waves are reflected off the objects in front of the lens, and these are absorbed by the silver halide particles on the surface of the film. Then the film is developed, and treated with a chemical solution to 'fix' the film, so that it is no longer sensitive to light. What is now obtained is a negative image of the object, in which the light areas are dark, and the dark areas appear light. Film negatives have long shelf lives, and can be used multiple times to create original photo prints.


I want to be the first person to see my photograph.

Vintage Camera



TV Camera



Camera Eye

The Copila is a marine animal that has eyes which work like television cameras do. It has two lenses and a retina that scans each image 10 times for better picture quality.

How do TV cameras work?

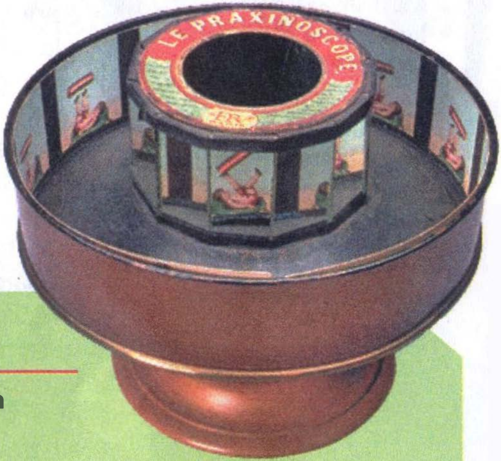
Television is a way of sending and receiving moving images and sounds over wires, or through the air by electrical impulses.

In a TV camera, thousands of light-sensitive detectors are arranged in a grid. Each detector is called a picture cell, or pixel. As light falls on each pixel, it produces an electrical signal. The signal from each pixel is sent down a cable in the form of a long coded message.

At the same time, a microphone records sounds that are occurring during the scenes. A vibrating magnet in the microphone changes these sounds into electrical signals too.

When a programme is broadcast, the electrical signals are turned into invisible bands of energy called radio waves that are picked up by a television set. The television set then changes the waves back into pictures and sounds.

Do you know how colours appear on your TV screen? The television screen is covered in rows of tiny pixels. Each tiny pixel can be made to glow. The pixels are red, green and blue- the primary colours of light. When the red, green and blue pixels glow together, our eyes see the colour white. Similarly, different colours are produced on the screen when different combinations of pixels glow. The brightness of each pixel can be altered too, giving a greater range of colours and shades.



Praxinoscope

Praxinoscope

The praxinoscope was a toy that converted still pictures into moving pictures. It consisted of a lamp surrounded by a ring of still pictures showing an object in different stages of movement. Each picture faced a mirror. By turning a handle, the ring could be turned fast enough so that the reflections in the mirror would merge, and it would look as though the object was moving.

The First Laser

The first working laser was built in 1960 by Theodore Maiman. Did you know that the word LASER stands for 'Light Amplification by Stimulated Emission of Radiation'?

Why is laser light special?

Lasers are a special form of light. Laser light does not exist in nature.

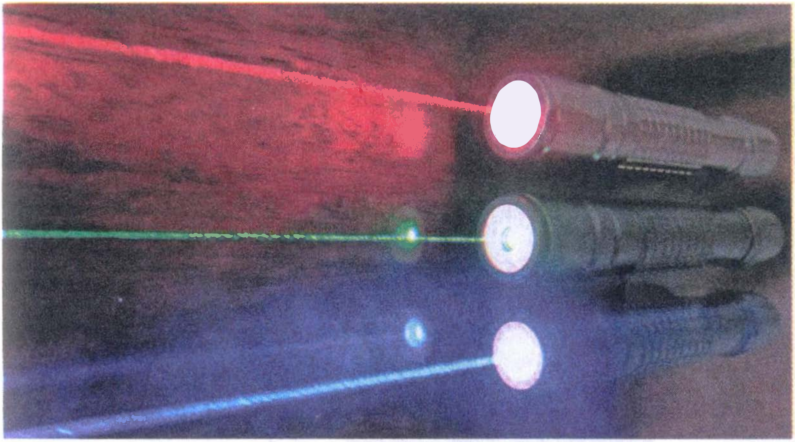
Ordinary light, like sunlight, is made up of many different wavelengths, or colours, of light. If you put all the different colours together, you get white light.

On the other hand, the light from a laser contains exactly one colour or wavelength rather than a lot of different wavelengths. So, laser light is said to be 'monochromatic,' meaning of one colour.

In laser light, all the high points or crests of the waves, and the low points or troughs are lined up, so that the waves move together, or are said to be 'coherent.'

Moreover, while light waves from ordinary sources such as light bulbs, or the Sun spread out in all directions, laser light waves all travel in the same direction, exactly parallel to one another. This means that laser light beams are very narrow, and can be concentrated on one tiny spot. This property makes the laser light 'collimated.'

The focused power makes laser light useful for cutting and



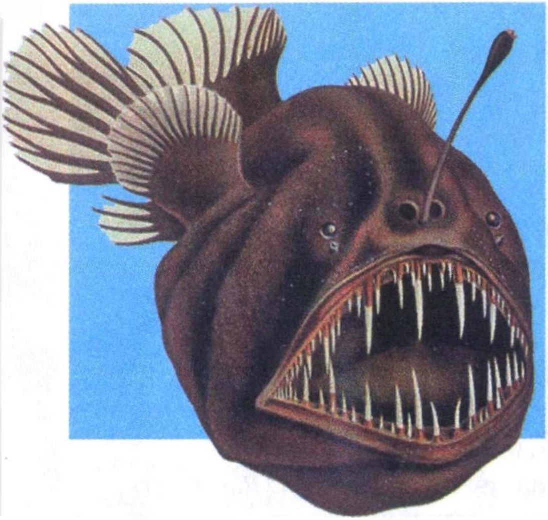
Red, Green and Blue Lasers

welding. It also makes it possible to control laser light very precisely, and make it do all kinds of useful things. Laser light is truly a wonderful thing- and only human technology can create it!

In our times, blood in films was black in colour.

Celluloid Film

In 1884, George Eastman of the United States invented a photographic film made of celluloid. It was strong but flexible enough to be wound into a roll. Within a decade, celluloid film was used not just for still photography, but to make movies as well.



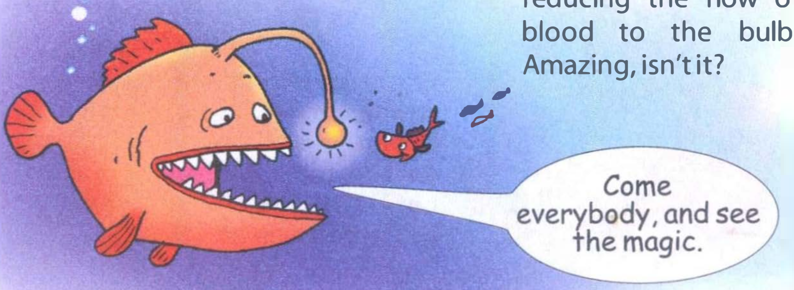
Angler Fish - An Illustration

What is bioluminescence?

The bodies of some living organisms- like fireflies and glowworms- are able to give off visible light. This phenomenon is known as bioluminescence.

Glowing animals create light by mixing chemical compounds in their bodies to produce light. This ability to produce light is most common among insects that fly at night, as they use light to communicate.

In the depths of the ocean, there is no natural light; so many deep-sea fish produce their own light. The angler fish and the flashlight fish have special light-producing bacteria in their bodies. The angler fish has a spine with a bulb at the end that it dangles in front of its mouth. It can switch the glow on and off by increasing or reducing the flow of blood to the bulb. Amazing, isn't it?


Come everybody, and see the magic.

Dr. Dennis Gabor

What is a hologram?

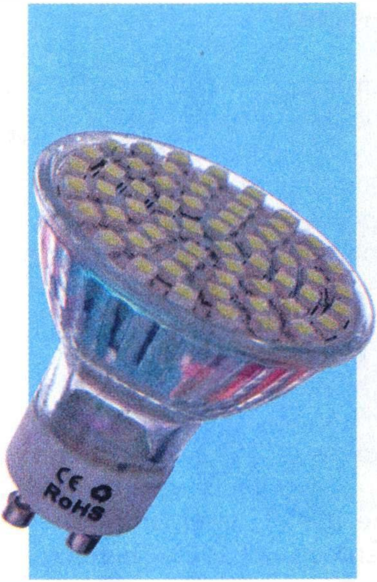
In a photograph, the image of the object that you see on paper is a flat one. Holograms are different. They give a three-dimensional image of an object using the special light from a laser.

Unlike photography, which only records the brightness and contrast of any object, a hologram records brightness, contrast, and depth.

The first hologram was produced in 1948 by Dr. Dennis Gabor, a researcher at the Imperial College of London. Gabor's early holograms were created without the use of laser, since laser wasn't invented until 1960. Therefore, his holograms were only capable of showing the slightest amount of depth-about the thickness of a postage stamp.

With the invention of the laser in 1960, researchers finally had the proper type of light to begin recording an object dimensionally. These early holograms required laser to both record, and view the image. It wasn't long, however, before new techniques allowed the hologram, although still requiring a laser to record, to be viewed with ordinary light.

The expensive lasers of the past have been replaced by the inexpensive laser pointers of today, which makes creating a hologram quite easy.



LED Spot Light

What are the advantages of LEDs?

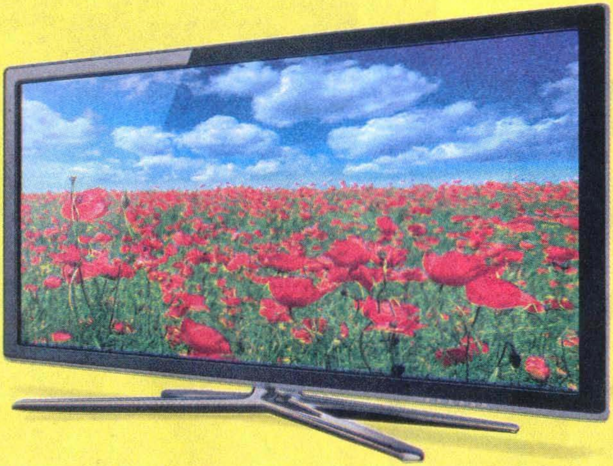
Light Emitting Diodes or LEDs are basically just tiny light bulbs that fit easily into an electric circuit. However, they don't have a filament that will burn, and get hot while producing light.

A diode is an electrical component with two terminals which conduct electricity only in one direction. Connecting a diode to an electrical current excites the electrons within the diode, making them release photons, which we see as light.

In the search for energy-efficient lighting, LEDs have proven to be the most efficient bulbs available. LEDs use at least 75 percent less energy than traditional incandescent bulbs, and last 25 times longer.

LEDs don't require, or emit great amounts of heat.

LED Bulbs



LCD TV

What are liquid crystal displays?

A liquid crystal display, or LCD is an electronic display device that operates by applying a varying electric voltage to liquid crystals.

Liquid crystals are substances that have properties between a liquid and a solid. To give an example, a crystal may flow like a liquid, but the molecules may be crystal-like. Liquid crystals are interesting because they don't exactly fall under the three main states of matter-solid, liquid, or gas.

Liquid crystals do not emit light directly, but have light modulating properties that have many applications in today's world. LCD consists of an array of tiny segments called pixels that can be manipulated to present information. LCDs are commonly used in video projection systems, as monitors for computers, and in flat-panel televisions.

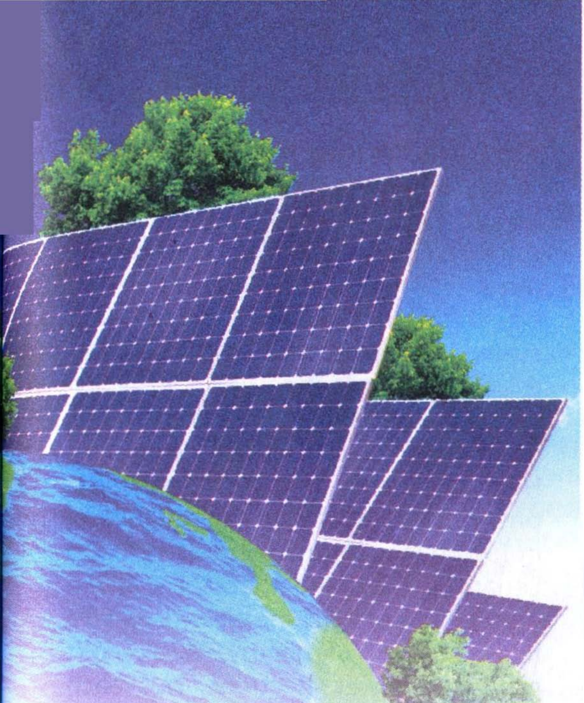
MORE ABOUT LIGHT

How does the Sun's energy reach us?

Did you know that only a small portion of the Sun's energy- just one thousandth of one millionth part- actually reaches the Earth as light and heat?

The Sun acts like a massive nuclear plant radiating energy into space, but most of this energy is either reflected back by the atmosphere into space or absorbed by the atmosphere, the land and oceans. Energy from the Sun is called solar energy.

Solar energy travels from the Sun to the Earth in rays. Some are light rays that we can see, while some are rays we can't see, like x-rays. The Sun's rays are able to reach the Earth by travelling through space, since light is able to travel through space



as well as through the air. The energy absorbed by the Earth becomes thermal energy, which warms the Earth, and the air around it.

A small portion of the energy that reaches us is trapped by green plants to make food. Plants act as energy transformers, capturing the light that falls on them first into chemical energy and then into the energy that makes them grow, by a process known as photosynthesis.

Plants are then eaten by animals and by us, either directly or indirectly through the animals that we eat. Even though such a minute part of the Sun's energy reaches us, it is still far more than we use.

STAR FACT

Cutting Lights

Long wave laser light is a very effective cutting tool. The beam can be directed to a surface so as to produce intense heat in a small area. This heat can cut through even steel. Laser light never becomes blunt like ordinary metal cutting tools, which is a very great advantage indeed.

Why is the discovery of the photoelectric effect a milestone in physics?

When X-rays, gamma rays, or certain other wavelengths of light are shined on certain kinds of matter, electrons are ejected. This phenomenon is known as the photoelectric effect.

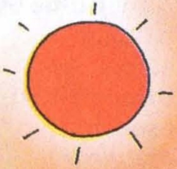
The photoelectric effect was discovered by German physicist Heinrich Hertz in 1887, and the phenomenon was investigated further in 1902 by the German physicist Philipp Lenard. He showed that, for a given wavelength of light, the electrons had a fixed amount of energy. Weak light produced fewer electrons, but each electron still had just and much energy as if the light had been bright. However, there was a link between wavelength and energy. The shorter the wavelength of light, the more energy the light had. Later, Albert Einstein explained the mechanism of photoelectric effect, and he awarded the Nobel Prize in Physics for the same, in 1921.

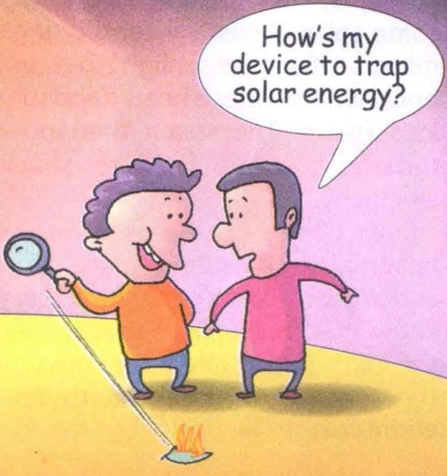
When a photon of a certain wavelength, and enough energy, falls on the surface of some metal, it will knock out electrons from the atom. If the photon energy is too low, the electron is unable to escape from the surface. The energy of the emitted electrons does not depend on the intensity of the incoming light, but only on the energy or frequency of the incoming light.

The photoelectric effect is important in history because it caused scientists to think about light and other forms of electromagnetic radiation in a different way.

Light Pressure

Light is made up of particles that exert pressure which is so little as to be insignificant. Sir William Crookes, a scientist proved this with a device known as a radiometer. In this device, light was used to turn a set of finely balanced vanes, but when all the air was removed from the device, the vanes stopped moving. This showed that the pressure of light alone could not move the vanes.




How's my device to trap solar energy?

Why are solar panels useful?

We know that solar energy is obtained from sunlight, and solar panels are large panels designed to trap sunlight. The panels are positioned to face the Sun, usually on south facing walls and roofs, and they convert light energy into electricity.

A large number of solar panels that are connected together can produce electricity on a commercial scale. In some solar plants, concentric rings of mirrors reflect the sunlight to a central boiler where water is heated and turned into steam. The steam then powers turbines that are used to generate electricity.

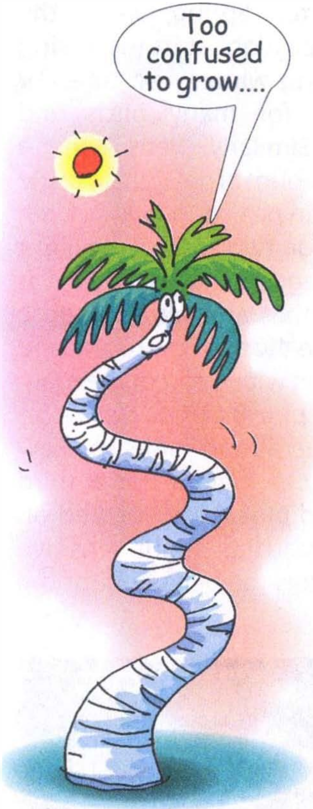
Solar panels can be used for water heating, space heating, space cooling, and to process heat generation. Did you know that the sunlight that shines on the Earth in just one hour could meet the world's energy demands for an entire year?

STAR FACT

Electrochromic Glasses

A new type of glass, called electrochromic glass, is covered by a thin coating of a special material which can be turned blue by passing electricity through it. It is used in car rearview mirrors to reduce headlight glare at night. It can also be used in windows to control the amount of light let into a room.

● *Dev Nath*


Too confused to grow....

What is the role played by light sensors in living things?

All living organisms contain biological sensors that can detect light. This is why plant shoots will naturally grow towards a light source, and this response to light is called phototropism.

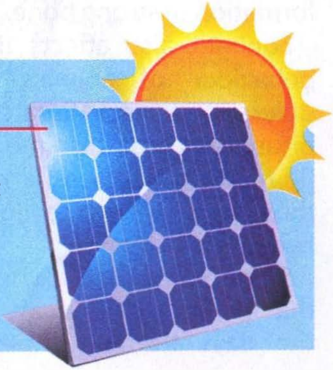
Plants need light for the process called photosynthesis, by which they prepare their food. Light also plays an important role in the flowering of plants. The opening and closing of some flowers' petals is also controlled by sunlight, and this kind of response to sunlight is called photonasty.

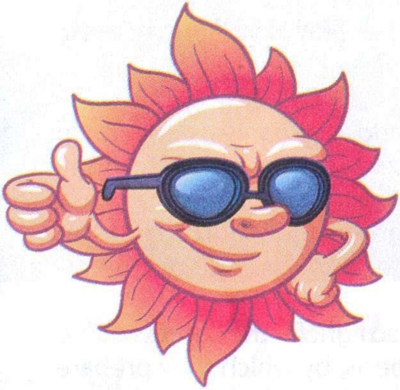
Some animals can respond to light in their surroundings, and the main trigger for these colour changes is light. Light is also used as a cue for the timing of daily and seasonal rhythms in both plants and animals.

CURIOUS FACT

Solar Cells

Solar or photo-voltaic cells convert solar energy into electricity. Solar cells are used for different purposes.





How are different animals affected by sunlight?

Every living organism depends on sunlight for its survival, in one form or the other. All of us benefit from the Sun's effect on our bodies, because sunlight on skin produces vitamin D, which is important in the formation of strong bones.

Sunlight also affects the behaviour of animals in different ways. Migratory birds know that it is time to fly to warmer places when the hours of daylight become shorter.

Some mammals also know that it is time to hibernate as the days become shorter and shorter. Spring, when the hours of daylight start increasing after a long winter, is a time for courtship for many birds and animals. Similarly, hens need a certain amount of daylight in order to maintain peak egg-laying. Even an hour or two less of daylight changes egg-laying patterns. It is believed that animals can sense changes in the quality of light, and its duration with a part of the brain called the pineal gland.

A reptile found only in New Zealand, the tuatara has a third eye, called pineal eye, located on top of its head that is light-sensitive and controls the behaviour of the animal.

Tuatara

STAR FACT

Natural Clocks

Some flowers will open and close their petals at a particular time every day - almost as though they have built- in clocks! Bats and insects have realized this and will come to suck honey from the flowers at that time.

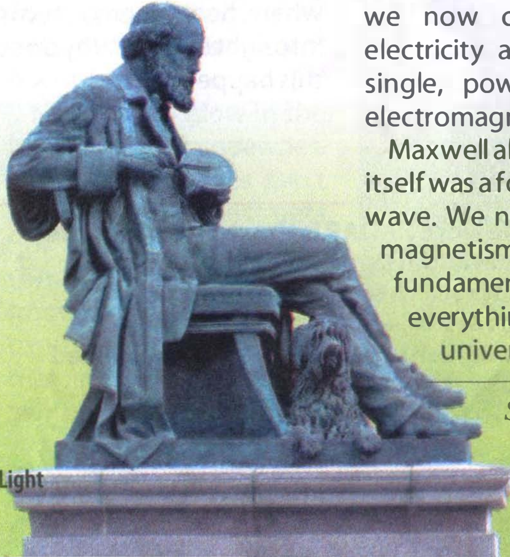
What do you know about electro-magnetism?

In the 19th century, European scientists discovered that electricity always makes magnetism when it moves about, or changes.

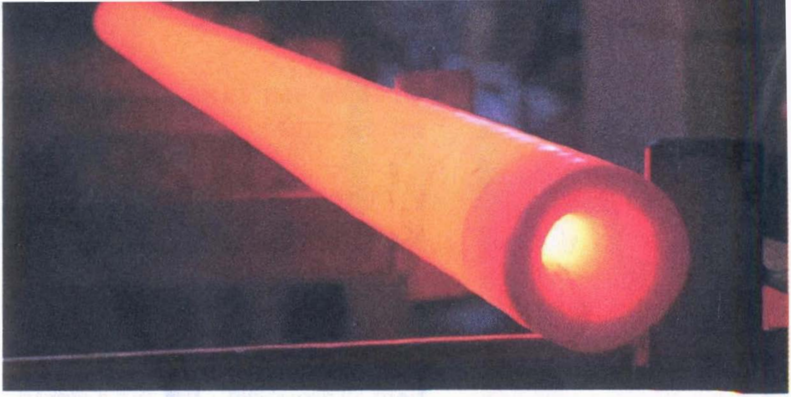
Every time an electric current flows in a wire, it generates a magnetic field all around it. Changing electric field, in short, produces magnetism. The reverse is true as well- you can make electricity using a changing magnetic field.

The first person to explain this was a Scottish physicist named James Clerk Maxwell. His theory summed all that was then known about electricity and magnetism in four relatively simple mathematical formulas. Maxwell's equations, as we now call them, combined electricity and magnetism into a single, powerful theory we call electromagnetism.

Maxwell also concluded that light itself was a form of electromagnetic wave. We now know that electro-magnetism is one of the four fundamental forces that control everything that happens in our universe.



Statue of Maxwell



Glowing Iron Rod

All that glitters is not gold, but now, all things can glow.
INFRARED

Why do things glow when they are very hot?

When an iron bar is heated to a very high temperature, it initially glows red, and then as its temperature rises, it glows white. This process is called incandescence. Incandescence is heat made visible when heat energy turns into light energy. Why does this happen?

CURIOUS FACT

RADAR

The word RADAR is the short form of the term Radio Detection and Ranging. A radar scanner emits very short radio waves .Objects in the path of these waves send back echoes that are picked up by the scanner.

Everything around us gives off both heat and waves of light called infrared light, which we cannot see. Even things that we think of as being very cold, like an ice cube, gives out some heat. As an object becomes warmer, its atoms emit much more wave energy, and the waves it produces become shorter and shorter. If it is warmed enough, the shorter waves will give off visible light as the object starts to glow.

When an object heats up, first it glows red, and then white when it becomes really, really hot. To put it in a nutshell, everything glows, not just hot objects.

Most things glow in the infrared frequencies, which human eyes can't see. When an object gets hot enough, it glows in the visible light frequencies, which we can see, and then we say that it is 'red- hot' or 'white-hot'!

X-Rays

X-Rays are waves of light we cannot see, but which carry more energy than visible light. They can pass through the soft parts of our body, but not through bone. X-Rays are used to show doctors what is going on inside your body, like whether you have fractured a bone or not.

● *Sneha Rao*

Why is UV light harmful to us?

Ultraviolet or UV light has a shorter wavelength than visible light, so we cannot see it.

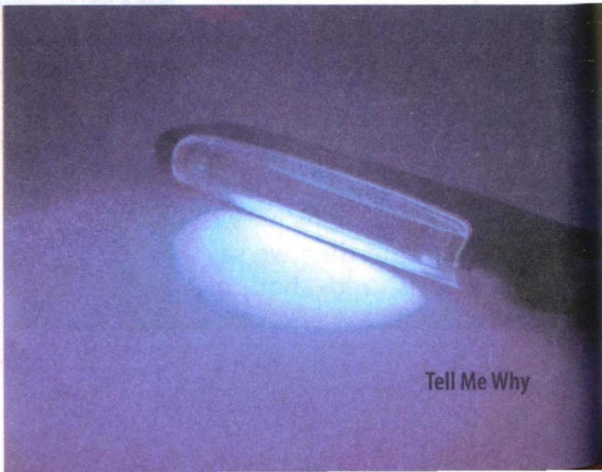
Ultraviolet radiation possess higher energy than visible light, and are responsible for causing our sunburns. UV light can cause some type of skin cancers also. UV light can be reflected strongly from the surface of water, and from white surfaces such as snow, and can cause snow-blindness. It is always better to wear protective goggles or sunglasses that filter out the UV light to prevent serious eye damage.

Though some UV rays from the Sun penetrate Earth's atmosphere, most of them are blocked from entering by various gases like ozone. However, increasing damage done to the ozone layer in the Earth's upper atmosphere means that more and more UV light is now reaching the surface of the Earth. This is dangerous to us.

STAR FACT

Cosmic Rays

Cosmic rays are highly energetic particles that originate in outer space. They are born from clouds of gas surrounding the ancient and massive explosions of distant stars, and they slam the Earth's upper atmosphere at very high speeds.



UV Light

How do plants use UV light?

Some insects like bees see a very different spectrum of colours from what we see, and they can see UV light. Bees play a very important role in nature, for they transfer pollen from one flower to another. These flowers are brightly coloured to attract insects like bees. Some of them are a bright red, a colour that bees can't see. This is where UV light plays a role. The red flowers reflect UV light- which is a colour that is visible to the bee. The bee is then attracted to the red flower, and flies to it to drink its nectar- and in the process, get some pollen on its body that will be transferred to another flower.

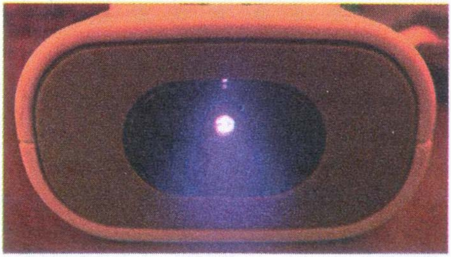
When some materials are lit by UV light, they emit a fluorescent glow. Some such chemicals are used in laundry detergents as whiteners. They bind to the natural fibres in clothes, and make them look brighter in sunlight. Ultra violet light is used to kill bacteria, hasten chemical reactions, and to identify some fluorescent minerals. UV light can also be used to show things the human eye can't see, which makes it very useful for forensic scientists.

Not a spacesuit, it's a UV protection suit.

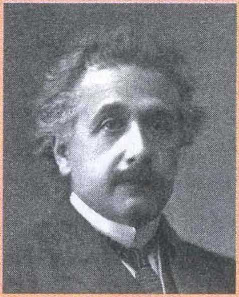
Why is infrared light useful to us?

Slightly more than half of the energy from the Sun arrives on Earth in the form of infrared radiation, and nearly everything around us gives off some form of infrared light. Infrared light has a wavelength that is a little longer than that of the red light than we can see, and it is not visible to human eyes. However, many animals like the piranha fish that live in the murky waters of the Amazon River, have the ability to detect infrared light. Some insects too have antennae that can detect infrared light, and this lets them see in the dark.

Today, research scientists are developing devices using infrared light that have many uses, both for the military, and in everyday life. Night-vision devices using active near-infrared illumination allow



Infra Red Light



Light and Gravity

Albert Einstein also put forward the idea that light can be bent both by refraction, and by gravity. Light ordinarily travels on a straight line path but it will follow a curved path if it passes through a strong gravitational field. This is called 'curved space,' and this explains why light becomes trapped in a black hole.

● *Radha Nair*

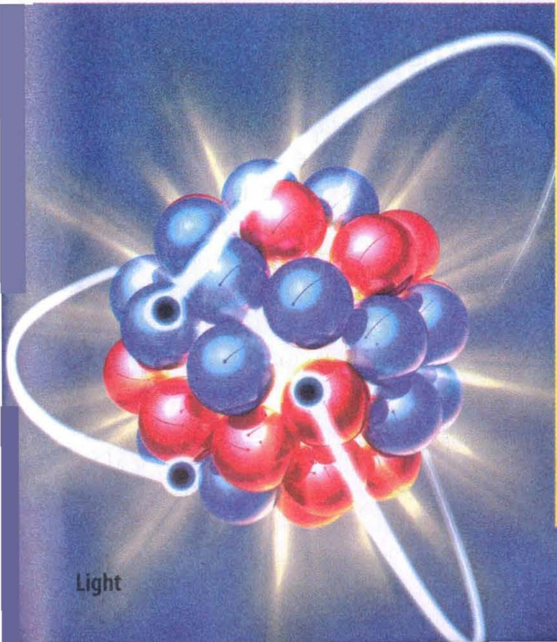
Piranha Fishes

people or animals to be observed without the observer being seen. Infrared light is used in industrial, scientific, and medical applications. So, though infrared light or 'IR' is just out of range of what the human eye can detect, we can still use infrared light to see things!

STAR FACT

Gamma Rays

Gamma rays have very short wavelengths. They carry very large amounts of energy, and can penetrate even metal and concrete. High levels of these rays are very dangerous, and can kill living cells. Because gamma rays can kill living cells, they are used to kill cancer cells without having to resort to difficult surgery. Gamma waves are generated by radioactive atoms and in nuclear explosions.



Einstein on his first US visit.

Why is the Theory of Relativity related to light?

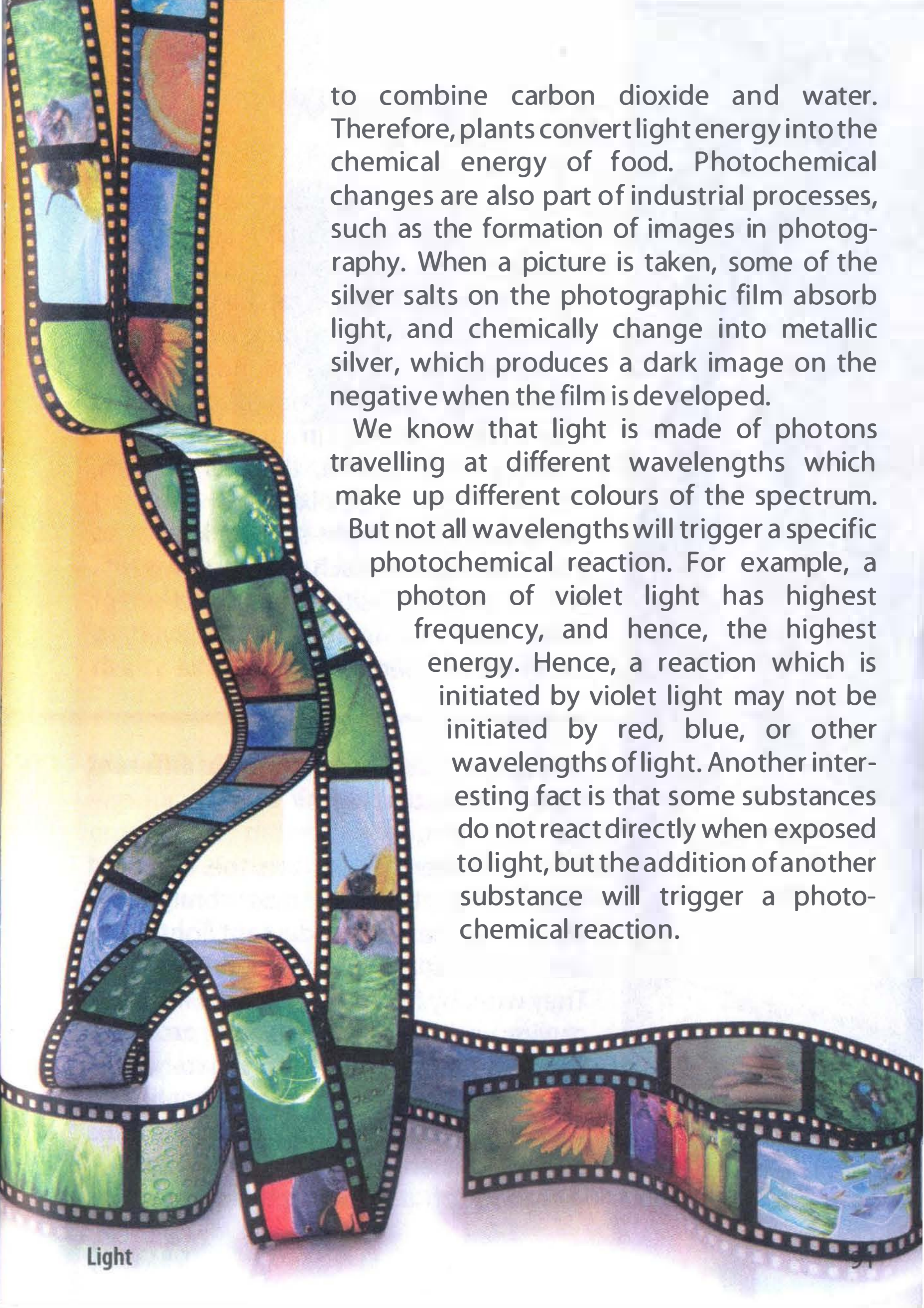
In March 1905, Albert Einstein, one of the greatest scientific minds of all time, explained the Quantum Theory of Light. According to this theory, light exists as tiny packets, or particles, which he called photons. Along with another scientist, Max Planck, Einstein proposed one of the most revolutionary ideas in twentieth century physics- that we live in a universe built out of tiny, discrete chunks of energy and matter.

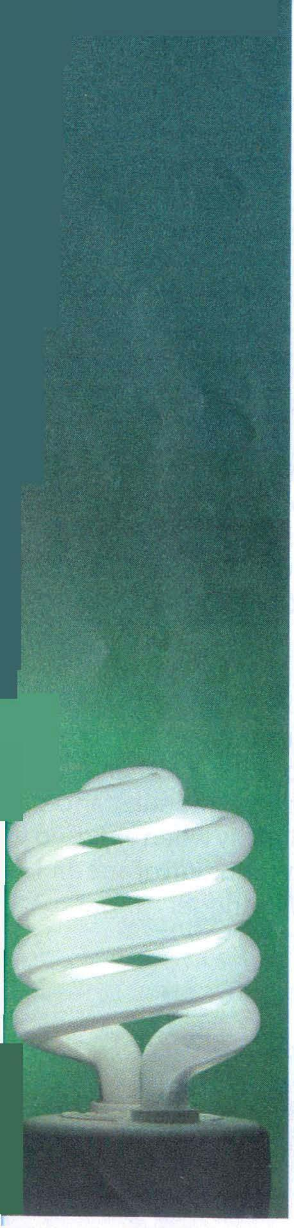
Later, in 1905, he published his Theory of Special Relativity. In this theory, he extended Galileo's principle of relativity, so that, it accounted for the constant speed of light. Einstein saw light as both a wave and a particle. He showed that nothing can move faster than light in a vacuum, and that the speed of light in a vacuum is always the same. His work revolutionized the way scientists viewed the world, and had a tremendous impact in the field of physics- especially in studies on light.

What are photo-chemical reactions?

Any reaction that takes place only in the presence of light is known as a photo-chemical reaction. The light may be visible light, infrared radiation, or ultra-violet radiation. Many photochemical reactions take place in nature, and the best example is photosynthesis. In photosynthesis, green plants make food using sunlight to combine carbon dioxide and water. Therefore, plants convert light energy into the chemical energy of food. Photochemical changes are also part of industrial processes, such as the formation of images in photography. When a picture is taken, some of the silver salts on the photographic film absorb light, and chemically change into metallic silver, which produces a dark image on the negative when the film is developed.

We know that light is made of photons travelling at different wavelengths which make up different colours of the spectrum. But not all wavelengths will trigger a specific photochemical reaction. For example, a photon of violet light has highest frequency, and hence, the highest energy. Hence, a reaction which is initiated by violet light may not be initiated by red, blue, or other wavelengths of light. Another interesting fact is that some substances do not react directly when exposed to light, but the addition of another substance will trigger a photochemical reaction.





How is digital photography different from film photography?

In a film camera, points of light are detected, and each point is recorded by a grain of chemical material on a film that is light-sensitive. The film can be processed in a lab, and turned into negatives, prints, or transparencies. The resulting image can be put in a book, framed and put on your desk, or just kept in a box.

In a digital camera, there is no film. Points of light called pixels are detected using an array of light-sensors known as photo-detectors. Each point represents colour and intensity. The collection of pixels forms an image that is saved to some kind of electronic media like a flash

Why are compact fluorescent bulbs different from incandescent bulbs?

Incandescent bulbs are the standard type of bulbs that were most common till some years back. Incandescent light bulbs are made of glass, and are round in shape . They work by heating a tungsten filament, or wire, until it glows. This is what produces the light that you see. Unfortunately, 90% of the energy used to generate that light is wasted as heat, making incandescent bulbs a very inefficient way to light your home.

Instead of a glowing filament, CFLs

Digital Camera

card, magnetic disc, or optical disc. The resulting file can be read by imaging software on a computer , and the image can then be printed .

To sum up, film cameras use rolls of film that have to be developed. Digital cameras use memory to store the images, and can be uploaded to your computer or ipod, so that you can see the picture directly.

contain argon and mercury vapour housed within a tube curved in different shapes. When an electric current passes through the mixture, the gas gets excited, and it produces ultraviolet light. The ultraviolet light, in turn, stimulates a fluorescent coating painted on the inside of the tube. As this coating absorbs energy, it emits visible light.

CFLs last a longer time than incandescent bulbs. In some tests, they burned brightly for 10,000 hours, whereas standard bulbs burned for just 800 to 1,500 hours. CFLs use significantly less energy - 75 percent less energy than incandescent light bulbs. This means that by using CFLs, you are not only saving electricity, but also helping the environment by reducing energy consumption and preventing greenhouse gas emissions that contribute to global climate change.

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What is sunburn ?

If you stay out in the Sun for too long, your skin may become red or dark, and even become painful and swollen. This is known as sunburn, and other symptoms may include fever, chills, nausea and vomiting, weakness and symptoms of shock.

Why does this happen? The reason is that sunlight has ultraviolet rays, and over- exposure to ultraviolet rays is harmful to both our skin and our eyes. As you near the tropics, the Sun's rays are more intense and more direct, so the risk of sunburn increases- and so does its severity. So, it is always better to wear a

Raman Effect

The great Indian scientist Sir C.V. Raman put forward a new theory on the scattering of light, for which he won the Nobel Prize in Physics in 1930. His theory, known as the Raman Effect, states that the wavelength of light changes after passing through a medium, and being deflected by the particles of that medium.

hat, or hold an umbrella and slather yourself with sunscreen lotion when going out during the hottest part of the day.

WINNERS

GK CONTEST - 3

Winners of the GK Contest -3, Freedom Fighters - held in the August issue of Tell Me Why.

1. Anjali Pakde
13,Ganesh Nagar,
Nandewar Road, Bharuch, Gujarat.
2. Saumay Shikher Raj
C/o Sri Hardeo Prasad,
Menka Bhawan; Bampass town, B.
Deoghar, Jharkhand.
3. Varad Kumar
415, Gaur Galaxy, Sector-5 ,Plot-5,
Vaishali, Ghaziabad, Uttar Pradesh.
4. Ananya
C/o Prabhash Kumar, Naka No.5
Darbhanga, Bihar.
5. Kanishakar Y.
17/1, 12^{e} Avenue, Ashok Nagar
Chennai, Tamil Nadu.

GK Contest -3, Freedom Fighters
ANSWERS

1. Dadabhai Naoroji
2. Bhagat Singh
3. Captain Lakshmi
4. Chandrasekhar Azad

GK CONTEST - 5

PHOTO QUIZ

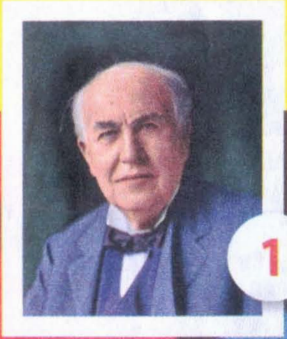
Here's a contest in which our readers have to identify five SCIENTISTS, from the pictures given here.

All you need to do is send us an email naming each person with the proper number. (PLEASE GIVE YOUR POSTAL ADDRESS ALSO IN THE EMAIL)

You are also welcome to send your answer by post.

Five winners will be awarded prizes.
In case there are more than five correct entries, the winners will be chosen by lot.

Last Date to receive entries:
October 25th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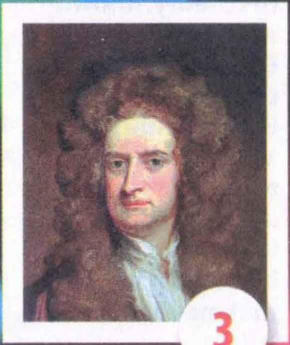
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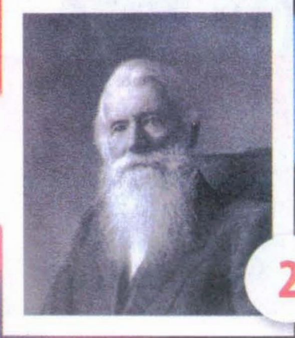
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FIVE LUCKY WINNERS WILL GET THE AMAZING SCIENCE KIT

Make a clock work using vegetable power

POTATO CLOCK

If you are sending your entry by post, superscribe this on your envelope.

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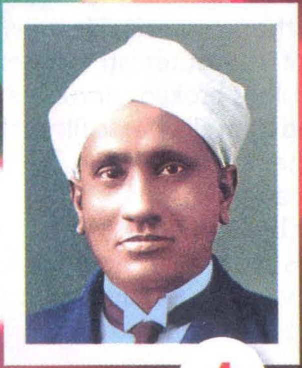

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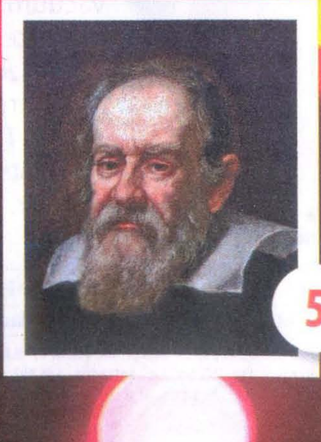

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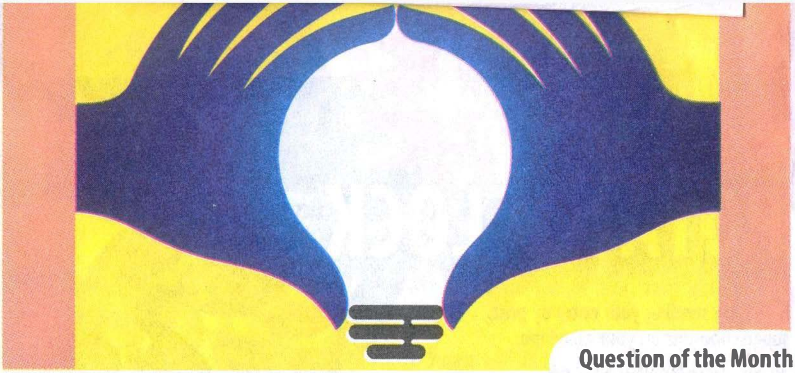

Question of the Month

I Wonder Why?

Why does an electric bulb make a bang when it is broken?

Have you ever noticed the breaking of an electric bulb and the consequent bang? This sound is produced by the air surrounding the bulb.

The inside of an electric bulb is vacuum. So, the pressure inside is lower than that of the outer atmosphere. When the bulb is broken, air rushes in at high speed from all sides to fill up the vacuum. The sudden surge of air produces a bang.

An electric bulb produces light when its filament is heated at a high temperature. The vacuum inside the bulb prevents the filament from oxidizing with air.

● *Alwin George*

Send us your questions
E mail: **childrensdivision@mmp.in**

MANORAMA TELL ME WHY - LIGHT

Editor: **Ammu Mathew** Editor-in-Charge: **A.V. Harisanker** *

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